REVIEW

Australian Energy Market Commission

# DECISION REPORT

## Last resort planning power - 2016 review

13 October 2016

Reference: EPR0051
Decision report

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**About the AEMC**

The AEMC reports to the Council of Australian Governments (COAG) through the COAG Energy Council. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the COAG Energy Council.

# Summary

The Australian Energy Market Commission (AEMC or Commission) has determined not to exercise its last resort planning power in 2016.

From the analysis undertaken for the 2016 review, the Commission has concluded that transmission network service providers are appropriately including inter-regional transmission priorities in their planning activities. The Commission therefore does not consider it is necessary to exercise the last resort planning power conferred on it under the National Electricity Rules.

**Background**

The last resort planning power allows the AEMC to direct one or more network service providers to apply the regulatory investment test for transmission to augmentation projects that are likely to relieve a forecast constraint on a national transmission flow path.

These flow paths include the infrastructure that allows electricity to be physically transferred across the NEM regional boundaries, known as interconnectors. Each interconnector will have a certain capacity which establishes an upper limit to the amount of electricity that can be carried across the interconnector.

In practice, limits elsewhere in the network can cause the actual transfer capacity of an interconnector being set at lower levels. For this reason, the Commission has regard to both the 'physical' interconnectors and to the transmission flow-paths and/or corridors leading up to the interconnectors when considering whether to exercise the last resort planning power.

Following on from this, the purpose of the last resort planning power is to ensure timely and efficient inter-regional transmission investment for the long term interests of consumers of electricity when other mechanisms to provide for the planning of this investment appear to have failed. The AEMC must exercise its power in accordance with requirements in the National Electricity Rules and the last resort planning power guidelines.[1]

The AEMC is also required to report annually on the matters which it has considered during that year in deciding whether to exercise the last resort planning power. To date, the AEMC has not exercised the last resort planning power.

**Commission's decision**

To assist it in determining whether to exercise the last resort planning power in 2016 and in accordance with the last resort planning power guidelines, the Commission has reviewed the transmission network service providers' annual planning reports, published in 2016, against the constraints on the transmission network forecast by the

1 AEMC, *Last resort planning power guidelines*, 24 September 2015.

Australian Energy Market Operator (AEMO) in the National Transmission Network Development Plans (NTNDPs) for 2015 and 2016, published in December 2014 and November 2015 respectively. The Commission has also considered the National Electricity Market (NEM) constraints report 2015 published by AEMO and other information such as relevant regulatory investment test reports published by the transmission network service providers.

The NTNDPs for 2015 and 2016 identified only one requirement for augmentation to the infrastructure connecting the different regions in the NEM, which was to address a transmission limitation across the Melbourne to south east South Australia zone. The current upgrade of the Heywood interconnector between Victoria and South Australia is the project alleviating this constraint. The upgrade is expected to be in full commercial service by March 2017.

Transmission network service providers continue to address or monitor constraints on the infrastructure connecting the NEM regions and the infrastructure within their networks that could impact on inter-regional electricity flows in their 2016 transmission annual planning reports. For example, TransGrid and Powerlink have committed to continue to monitor constraints on the Queensland-NSW interconnector. Similarly, ElectraNet has completed works to enable greater flow of electricity across the Tailem Bend to Tungkillo transmission corridor leading to the Heywood interconnector.

As the Commission has found that transmission network service providers are adequately addressing inter-regional transmission constraints in their planning processes it has decided not to exercise the last resort planning power in 2016.

**Other interconnector studies in the NEM**

While AEMO did not identify any constraints on the infrastructure connecting the NEM regions in the NTNDPs for 2015 and 2016 that were not already being dealt with, some electricity market stakeholders are actively considering building new interconnectors for a range of reasons that are not limited to forecast inter-regional constraints.

ElectraNet is considering a range of potential interconnector options to either New South Wales or Victoria. ElectraNet considers that a new interconnector may amongst other matters:

- support development of renewable generation;
- improve export and import capability; and
- enhance reliability to parts of South Australia and Victoria.[2]

A RIT-T process is expected to commence on a potential new interconnector to South Australia (from either Victoria or New South Wales) later this year.[3]

2 ElectraNet, South Australian transmission annual planning report, June 2016, p24.

In a separate development, the Commonwealth and Tasmanian Governments have initiated a feasibility study on a second interconnector from Tasmania to Victoria. The purpose of this study is to assess:

- the potential for a second interconnector to facilitate large scale renewable investment in Tasmania;
- how a second interconnector could contribute to system security, both in Tasmania and in the NEM more broadly; and
- the costs and benefits to consumers, both in Tasmania and the NEM, of a second interconnector from Tasmania to Victoria.

A preliminary report on the study was released on 21 June 2016. A final report is due by the end of January 2017.

In addition to the interconnector studies described above, the COAG Energy Council has tasked officials to review the effectiveness of the RIT-T in the current market environment.[4]

In particular, the review will examine:

- whether there is scope to make the RIT-T process more efficient and timely; and
- whether the design of the current RIT-T remains appropriate to current and future needs, with particular regard to:
  - whether the RIT-T remains the appropriate mechanism for the assessment of strategic interconnection investment for the development of a truly national, efficient, interconnected NEM; and
  - whether the parties responsible for assessing and making decisions on strategic interconnection investment are appropriate in the context of the development of a truly national, efficient, interconnected NEM.

The AEMC is on the working group conducting the review. The working group also consists of representatives from the Commonwealth and state and territory governments, the Australian Energy Regulator (AER) and AEMO. The working group are to prepare a report for energy ministers' consideration at the December 2016 COAG Energy Council meeting.[5]

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3 The South Australian Government is contributing $500,000 towards the costs of the RIT-T. See: www.premier.sa.gov.au/index.php/jay-weatherill-news-releases/697-state-budget-2016-17-study-into-new-interconnector, viewed 29 September 2016.

4 COAG Energy Council, *Meeting Communique*, 19 August 2016.

5 COAG Energy Council, *Review of the Regulatory Investment Test for Transmission: Consultation paper*, 30 September 2016, pp4-5.

# Contents

# 1 Background and approach

## 1.1 Background

The interconnected transmission network in the national electricity market (NEM) is important for facilitating a reliable supply of electricity to consumers and to support the NEM wholesale market by allowing electricity to be bought and sold across regions.

Responsibility for planning of the transmission network in the NEM is generally shared between the Australian Energy Market Operator (AEMO) in its role as National Transmission Planner and the transmission network service providers (TNSPs) in the NEM.[6] These responsibilities are complemented by the Australian Energy Market Commission’s (AEMC or Commission's) last resort planning power (LRPP).

The LRPP allows the AEMC to direct one or more network service providers (NSPs) to apply the regulatory investment test for transmission (RIT-T) to augmentation projects that are likely to relieve a forecast constraint on a national transmission flow path.[7] These flow paths include the infrastructure that allows electricity to be physically transferred across the NEM regional boundaries, known as interconnectors.

The purpose of the LRPP is to ensure timely and efficient inter-regional transmission investment for the long term interests of consumers of electricity when other mechanisms for the planning of this investment appear to have failed. Being a last resort mechanism, it is designed to only be utilised where there is a clear indication that regular planning processes have resulted in a planning gap regarding inter-regional transmission infrastructure.

The AEMC must decide whether, and if so how, to exercise the LRPP in accordance with requirements in the National Electricity Rules (NER) and with its LRPP guidelines. The NER also require the AEMC to report annually on the matters which it has considered during that year in deciding whether to exercise the LRPP. This is the subject of this report.

Further information on the interconnection of the NEM and network constraints is provided in Appendix A of this report.

6 Note that AEMO is also responsible for planning and directing augmentations to the electricity transmission network in Victoria. This means it is a TNSP for these purposes under the National Electricity Rules.

7 Clause 5.10.2 of the NER defines a potential transmission project as an investment in a transmission asset of a TNSP which is: an augmentation; has an estimated capital cost in excess of $5 million, as varied in accordance with a cost threshold determination; and the person who identifies the project considers is likely, if constructed, to relieve forecast constraints in respect of national transmission flow paths between regional reference nodes.

## 1.2 Commission's approach to exercising the last resort planning power

As set out in the LRPP guidelines, the AEMC adopts a three stage approach to the LRPP:

- The first stage involves reviewing relevant planning documents to determine whether there are any inter-regional constraints in the NEM that have not been adequately examined by TNSPs, that is, whether there are any planning gaps.
- The second stage is only undertaken if any planning gaps have been identified in stage one. It involves more closely examining these gaps to determine whether exercising the LRPP is likely to meet the national electricity objective.
- The third stage is only undertaken if the AEMC considers it appropriate to exercise the LRPP in stage two. It focuses on who should be directed to undertake a RIT-T.

More detail on this approach can be found in the AEMC's LRPP guidelines.[8] These guidelines were recently updated by the AEMC.[9]

8 AEMC, *Last resort planning power guidelines*, 24 September 2015.

9 AEMC, *Review of the last resort planning power guidelines final decision*, 24 September 2015.

# 2 Commission's considerations and conclusions

The Commission has concluded that TNSPs are adequately considering inter-regional transmission constraints in the NEM and has therefore decided not to exercise the LRPP in 2016 in accordance with the requirements in the NER.

In making this decision the AEMC has considered:

- the National Transmission Network Development Plan (NTNDP) for 2015 published by AEMO in 2014 and the NTNDP for 2016 published by AEMO in 2015;
- the 2016 transmission annual planning reports for each region of the NEM published by TNSPs;
- the NEM constraint report for 2015 published by AEMO; and
- relevant regulatory investment tests for transmission that have recently been undertaken.

While both the NTNDP for 2015 and 2016 have been considered, the Commission has given significantly more weight to the NTNDP for 2016 as the constraints on the network forecast by AEMO in this report are based on more recent electricity demand and supply forecasts.

Table 2.1 below sets out a summary of the analysis supporting the Commission's conclusion. In particular, it sets out inter-regional network constraints identified by AEMO in the NTNDP and how the relevant TNSPs are addressing these constraints in their annual planning reports. The analysis is presented by NEM interconnector.

Each interconnector will have a certain capacity which establishes an upper limit to the amount of electricity that can be carried across the interconnector. In practice, limits elsewhere in the network can cause the actual transfer capacity of an interconnector being set at lower levels. For this reason, the Commission has regard to both the 'physical' interconnectors and to the transmission flow-paths and/or corridors leading up to the interconnectors when considering whether to exercise the last resort planning power.

The physical location of the interconnectors in the NEM are set out in Figure 2.1.

Further details and analysis supporting the Commission's conclusion are contained in Appendices C to H of this report. In addition, Appendix B of this report provides a summary of the information in the planning reports considered by the AEMC.

**Figure 2.1 Location of interconnectors in the NEM**

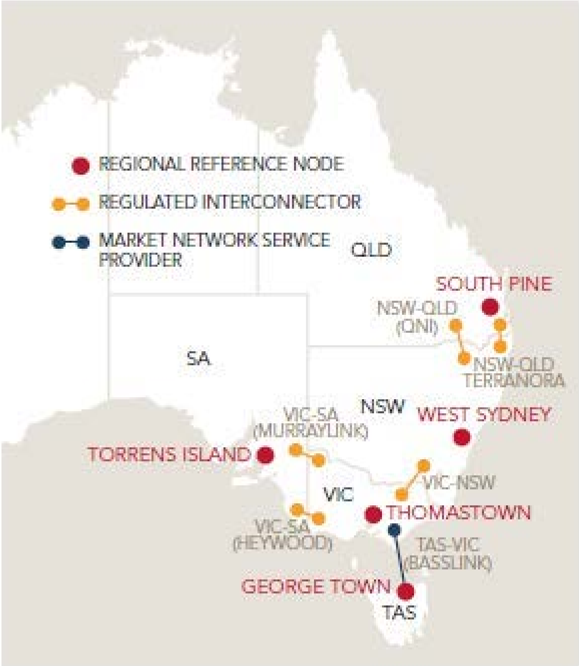


**Table 2.1 Constraints relating to NEM interconnectors and TNSP projects addressing these constraints**

| Interconnector | Constraint identified by AEMO in the NTNDP | Responsible TNSP | Project in annual planning report to address constraint and status |
|---|---|---|---|
| QNI | Future constraints in northern NSW, in particular between Liddell and Tamworth, at times of high northward flows on the QNI interconnector. | TransGrid | Increase system capacity between Hunter Valley, Tamworth and Armidale. Contingent on QNI being upgraded and new generation being connected in the northern NSW. TransGrid have committed to undertaking a re-evaluation of the QNI upgrade with Powerlink. |
| Terranora (Directlink) | Future constraints in northern NSW, in particular between Lismore and Dunoon/Mullumbimby, at times of high northward flows from wind generation from New South Wales to Queensland. | The 132 kV network between Lismore and Dunoon/Mullumbimby belongs to Essential Energy. | Essential Energy has advised AEMC staff that it is aware of the constraint identified by AEMO and is considering whether to include it as part of its 2016 distribution annual planning report. |
| Vic-NSW | Transmission limitations between Canberra and Central NSW NTNDP zones. This is contingent upon high wind generation in the Canberra zone when power flows from the South West NSW zone to Canberra zone. | TransGrid | Projects relating to the uprating of the capacity of the transmission network between the Snowy Mountains region and Sydney being investigated could address this need. A potential project could be initiated although more detailed modelling would be required to help identify a preferred option. |
| | Transmission limitation on South Morang 500/330 kV transformer. AEMO considers this is present when there is high export from Victoria to New South Wales. | AEMO | A possible network solution through a new 500/330 kV transformer at South Morang, a Braking resistor at Loy Yang, and uprating of the South Morang–Dederang 330 kV lines. These projects are not committed as yet. AEMO is monitoring changes to the Victoria generation mix that could trigger a RIT-T. |

| Interconnector | Constraint identified by AEMO in the NTNDP | Responsible TNSP | Project in annual planning report to address constraint and status |
|---|---|---|---|
| | Transmission limitations on Dederang-South Morang 330 kV circuits. AEMO considers that this constraint is present when there is high transfer between Victoria and New South Wales (export or import). | AEMO | Two options are identified:<br><br>Up-rating the two existing lines 82 ºC (conductor temperature) operation and series compensation.<br><br>Installing a new 330 kV, 1,060 MVA single circuit line between Dederang and South Morang with 50% series compensation to match the existing lines.<br><br>Both of these projects are identified but not committed as yet. AEMO is monitoring changes to the Victoria generation mix that could trigger a RIT-T. |
| | Transmission limitations on Eildon-Thomastown 220 kV line. AEMO considers that this constraint is present when there is high transfer between Victoria and New South Wales (export or import). | AEMO | Two options are identified:<br><br>Installing a wind monitoring scheme. Project is not committed as yet.<br><br>Up-rating the Eildon– Thomastown 220 kV line, including terminations to 75 ºC operation. Project is not committed as yet. |
| Heywood | A transmission limitation on the Northern South Australia to Adelaide 275 kV corridor as a potential economic constraint. This constraint may bind during high levels of wind generation in the North South Australia zone. | ElectraNet | Various projects covered in section F.3.4 of this report. |

| Interconnector | Constraint identified by AEMO in the NTNDP | Responsible TNSP | Project in annual planning report to address constraint and status |
|---|---|---|---|
| | Transmission limitations on the Tailem Bend-Tungkillo transmission corridor. | ElectraNet | Two potential projects (cumulatively) will address this constraint:<br><br>Uprating the Tailem Bend to Tungkillo 275 kV line and the Tailem Bend to Mobilong 132 kV line from 80°C design clearances to 100°C design clearances. It will enable higher transfers across the Tailem Bend to Tungkillo corridor by about 132 MVA. Works on Tailem Bend to Tungkillo have been completed as of August 2016.<br><br>String vacant 275 kV circuit between Tailem Bend and Tungkillo and install dynamic reactive support at Tailem Bend. A potential project taking up to 4 years with 1-2 years to undertake a RIT-T and 2 years for delivery. |
| Murraylink | A transmission limitation on the Northern South Australia to Adelaide 275 kV corridor as a potential economic constraint. This constraint may bind during high levels of wind generation in the North South Australia zone. | ElectraNet | Various projects contained in section G.3.3 of this report. These potential projects would take between 1 and 7 years to complete, including RIT-Ts for some of them. |
| | A transmission limitation on the 132 kV transmission network in the Mid North region of South Australia. This constraint may bind during high levels of wind generation in the North South Australia zone. | ElectraNet | Reconfiguring of the Mid North 275 kV network. This is a potential project dependent upon location of generation and load. |

| Interconnector | Constraint identified by AEMO in the NTNDP | Responsible TNSP | Project in annual planning report to address constraint and status |
|---|---|---|---|
| | A transmission limitation on the 132 kV transmission network in the Riverland area of South Australia. This constraint may bind during high levels of wind generation in the North South Australia zone. | ElectraNet | Two potential projects could together address this constraint:<br><br>A potential new interconnector between South Australia and either Victoria or New South Wales. Lead time for the new interconnector project is 1-2 years to undertake a RIT-T and 3-5 years to undertake detailed design and delivery.<br><br>ElectraNet is engaging APA (operator of the Murraylink interconnector), AusNet Services and AEMO to consider the technical feasibility, cost, and potential benefits of implementing frequency control through the Murraylink interconnector. No timing is reported for this potential project. |
| | A transmission limitation in the Central Victoria zone on the Ballarat-Horsham 220 kV line. This constraint may bind during high levels of wind generation connected between Ballarat and Horsham and/or between Horsham and Redcliffs. | AEMO | AEMO will commence a RIT-T for augmentation in North West Victoria later this year. Any potential project will be subject to this process. |

## Abbreviations

| | |
|---|---|
| AEMC or Commission | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| LRPP | last resort planning power |
| NEMDE | national electricity market dispatch engine |
| NER | National Electricity Rules |
| NTNDP | National Transmission Network Development Plan |
| QNI | Queensland–New South Wales interconnector |
| RIT-T | regulatory investment test for transmission |
| TNSP | transmission network service provider |
| MVAr | mega volt amps (reactive) |

# A Interconnection and constraints

## A.1 Interconnection

Almost 40,000 km of transmission lines and associated infrastructure make up the physically interconnected NEM transmission network.[10]

Physical interconnection allows electricity to flow across the entire network, facilitating the NEM as a single market. Interconnection has a number of efficiency benefits, as it:[11]

- allows electricity in lower priced regions to flow to higher priced regions, thereby reducing the cost of meeting demand in the NEM and the degree of price separation between regions;
- can contribute to a reduction of price volatility in regions;
- enables retailers to access cheaper sources of generation, thereby benefiting consumers by increasing competition between generators and retailers; and
- allows optimisation of investment in generation and transmission as interconnection may defer the need for investment in generation or transmission which may otherwise have taken place.

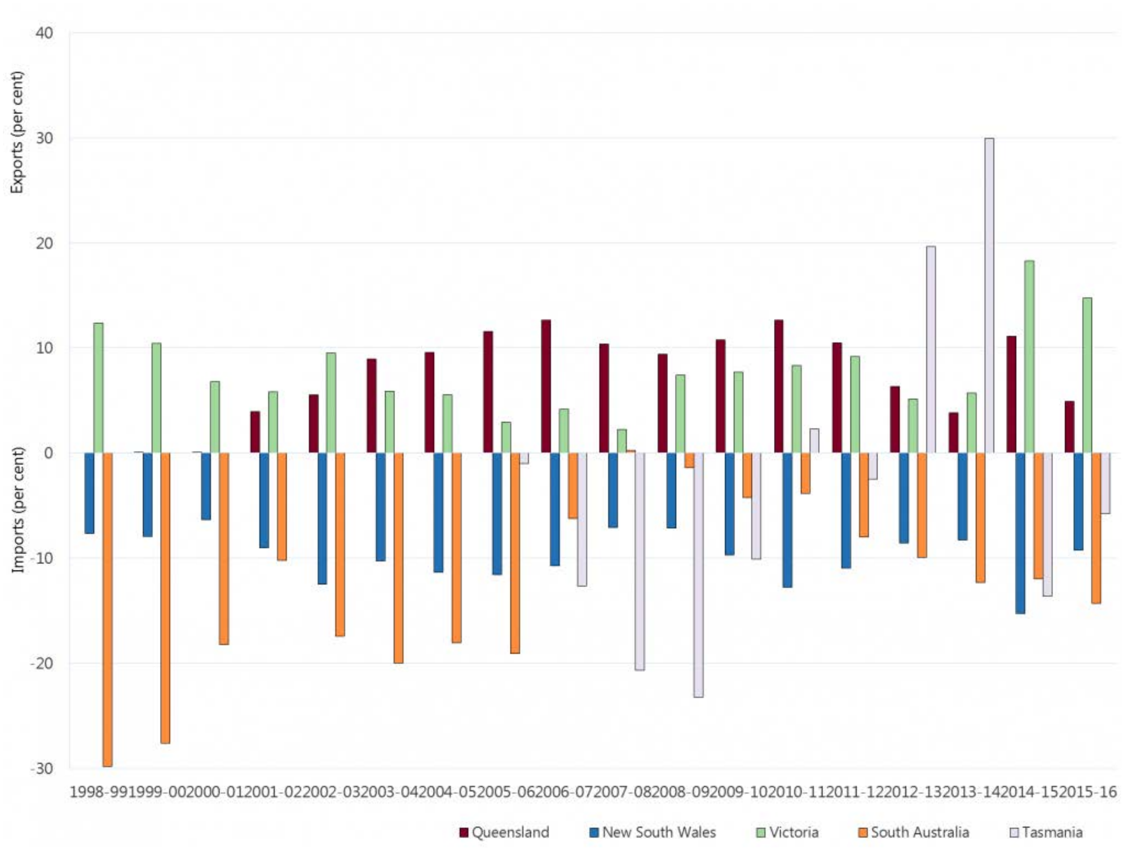
Interconnection also contributes to reliability of supply across the NEM as regions can draw upon a wider pool of reserves.

The level of interconnection in the NEM has facilitated inter-regional trade between NEM regions. Depending on local circumstances - such as available generation, the cost of generation and levels of demand - regions are either net importers or net exporters of electricity. Figure A.1 expresses inter-regional trade in net flows as a percentage of regional energy demand for each region of the NEM.

10 AEMO website, www.aemo.com.au/Electricity/National-Electricity-Market-NEM, viewed 3 August 2016.

11 See also: Productivity Commission, *Electricity Network Regulation, Final Report*, Chapter 16: The role of interconnectors.

**Figure A.1** **Inter-regional trade, in net flows, as a percentage of regional electricity consumption**




Source: Industry statistics on the Australian Energy Regulator website. Available from www.aer.gov.au/industry-information/industry-statistics, last viewed 25 July 2016.

The growing share of electricity generation coming from renewable energy sources may increase the potential benefits of interconnection. This is because:

- sources of renewable energy are often further removed from centres of demand than conventional generation;
- the potential for price separation between regions is likely to increase as a result of lower-cost renewable energy in some regions; and
- the intermittence of renewable energy sources such as wind and solar requires sufficient complementary generation from other power sources in order to secure a reliable supply. This complementary generation may be provided by a generator in another region.

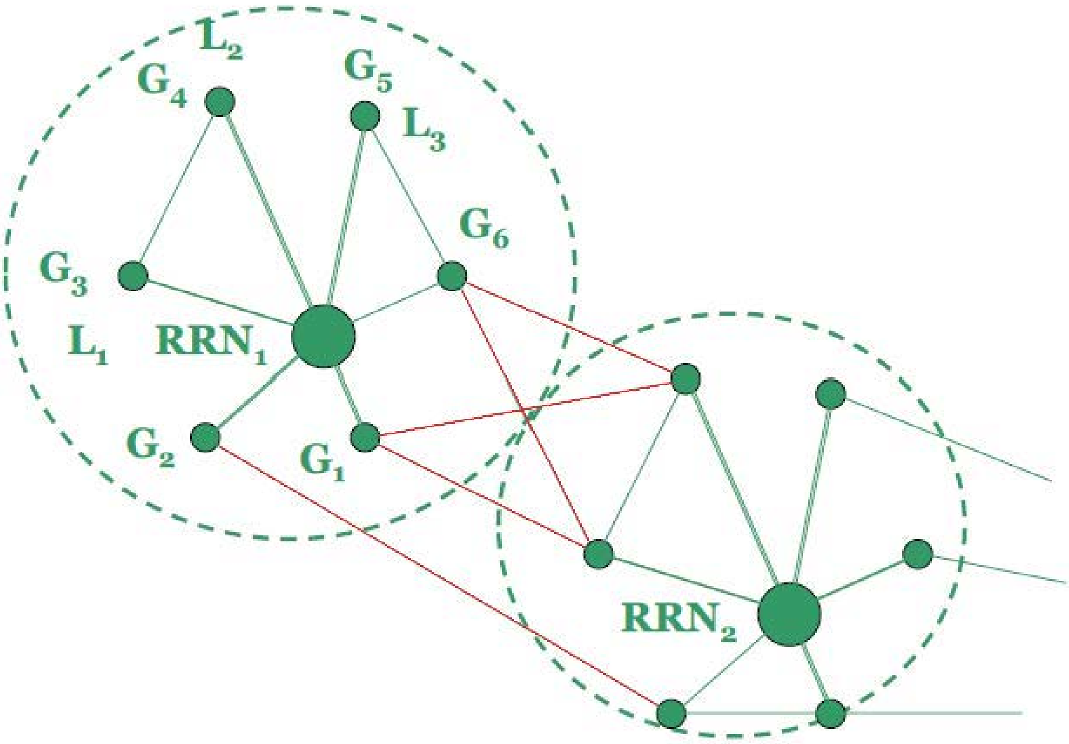
## A.2 Interconnectors

The importance of the transmission network in the functioning of the NEM leads to the need for it to be reliable, as outages or failures of the network can be disruptive and costly.

TNSPs operate the transmission networks in the five NEM regions and are responsible for ensuring a reliable supply of electricity over the transmission system to consumers in their respective regions. These businesses also need to comply with transmission reliability and system security requirements which guide how they plan and operate their networks.

For the purpose of network planning, an 'interconnector' refers to transmission network infrastructure that enables electricity to be carried across NEM regional boundaries. In this sense, interconnectors consist of transmission infrastructure located on each side of a regional boundary, connected by a set of high-voltage transmission lines or cables. Physically, this infrastructure cannot necessarily be distinguished from other parts of the transmission network. Schematically, this can be represented by the diagram in Figure A.2. The red lines in this diagram represent the physical interconnectors connecting two regions.

**Figure A.2 Stylised representation of interconnectors as cross-border infrastructure**

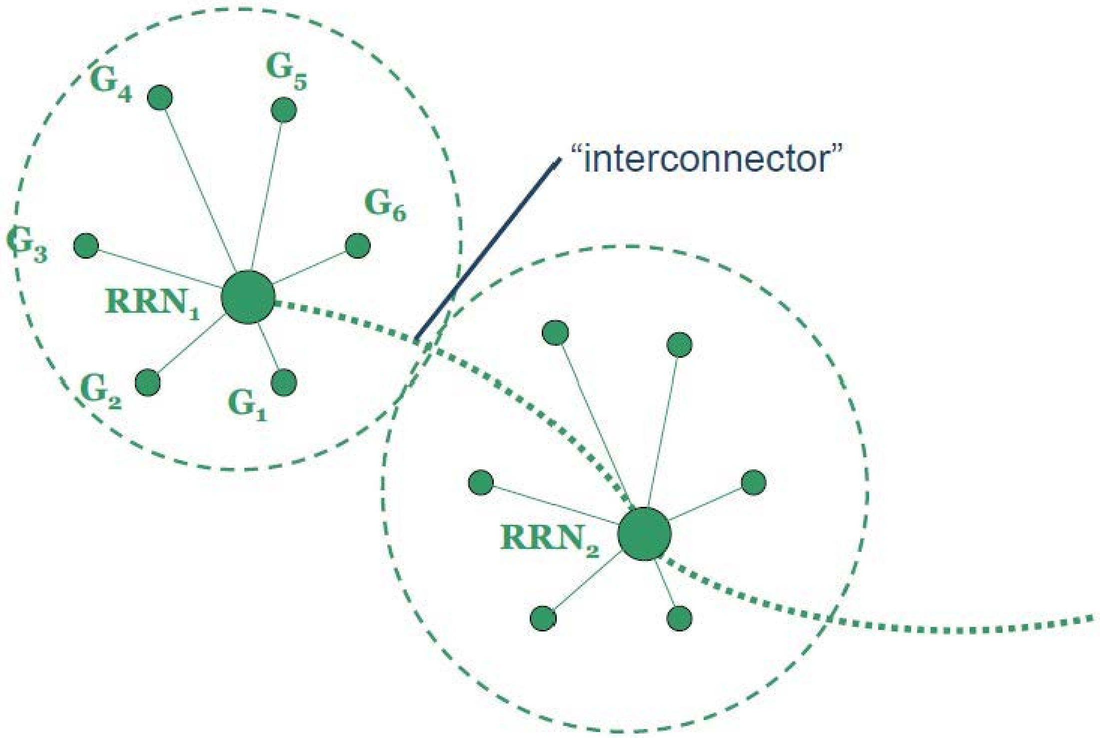



Note: ‘RRN’ refers to regional reference node, ‘G’ to generator and ‘L’ to load (demand) centres. The red lines represent the physical interconnectors connecting the regions.

Source: AEMO, Electricity network regulation – AEMO’s response to the Productivity Commission issues paper, 21 May 2012, p30 (adapted).

For the purpose of dispatch and settlement, interconnectors are a notional concept, connecting two regional reference nodes in different regions of the NEM, as illustrated by Figure A.3. In this sense, they are a mathematical representation of the movement of electricity from one regional reference node to another. That is, the interconnectors represent the transmission flow-paths within each NEM region that link the two regional reference nodes. For this reason, the Commission has regard to the 'physical' interconnectors, in addition to the transmission flow-paths and/or corridors leading up to the interconnectors when considering whether to exercise the last resort planning power.

**Figure A.3 Treatment of interconnectors for market purposes**




Source: AEMO, Electricity network regulation – AEMO's response to the Productivity Commission issues paper, 21 May 2012, p31.

There are two types of interconnectors in the NEM: regulated and market (or unregulated) interconnectors.[12]

A regulated interconnector is an interconnector that forms part of a TNSP's regulated assets. The TNSP owning the interconnector can recover a maximum annual revenue set by the Australian Energy Regulator. The revenue is collected by distribution network service providers as part of the network charges levied on retailers. Generally, a TNSP is required to undertake a regulatory investment test for transmission (RIT-T) when planning for the building of a new regulated interconnector or increasing the capacity of an existing regulated interconnector.[13]

A market (or unregulated) interconnector derives revenue by trading on the spot market. This is done by purchasing energy in a lower priced region and selling it to a higher priced region, or by selling the rights to revenue traded across the

12 See AEMO website, www.aemo.com.au/Datasource/Archives/Archive1027, viewed 21 September 2015.

13 The RIT-T is discussed in more detail in Appendix B.4 of this report.

interconnector. Expansions of market interconnectors are not required to undergo the regulatory investment test evaluation. The only market interconnector currently operating in the NEM is Basslink connecting Tasmania and Victoria.

Each interconnector will have a certain capacity which establishes an upper limit to the amount of electricity that can be carried across the interconnector. In practice, limits elsewhere in the network are the principal reason that the actual transfer capacity is often set at lower levels. This also explains why actual capacity may vary between seasons, between peak and off-peak periods and according to flow directions.

The current interconnectors in the NEM, including their regulatory status, are listed in Table A.1.

### Table A.1 Interconnectors in the NEM

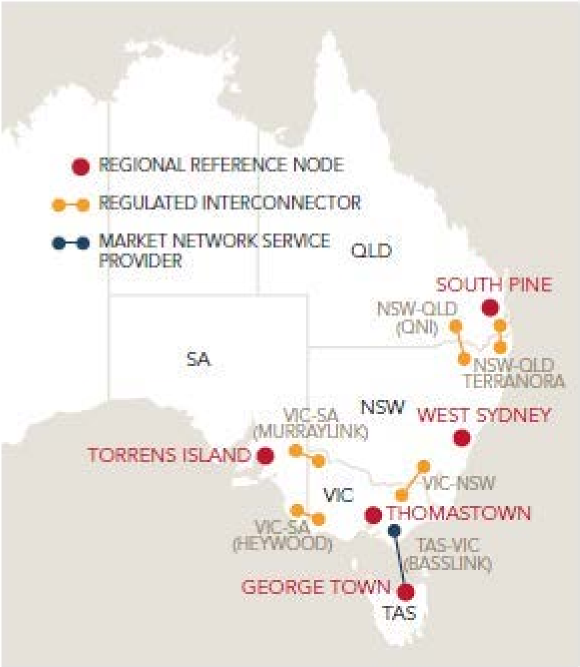
| Name | Region | Regulated or market[14] |
|---|---|---|
| QNI | Between Queensland and NSW | Regulated |
| Terranora (Directlink) | Between Queensland and NSW | Regulated |
| VIC to NSW | Between Victoria and NSW | Regulated |
| Heywood | Between South Australia and Victoria | Regulated |
| Murraylink | Between South Australia and Victoria | Regulated |
| Basslink | Between Tasmania and Victoria | Market |

Source: AEMO website, www.aemo.com.au/Datasource/Archives/Archive1027, viewed 30 September 2016.

Figure A.4 illustrates where the interconnectors, being those elements of the transmission network that cross state boundaries, are physically located.

14 Market interconnectors are unregulated.

**Figure A.4 Location of interconnectors in the NEM**




Source: An introduction to Australia's National Energy Market, July 2010.

AEMO publishes details on the performance of interconnectors on a quarterly basis, which assists in scheduling and dispatch functions.[15]

## A.3 Network constraints

The ability of the network to carry electricity (the 'transfer capability') is in practice affected by a range of factors.[16]

Outages or maintenance operations may for example cause generators or particular network elements to be unavailable, or operated at reduced capacity for a certain period of time.

Also, individual network elements have technical design limitations. When a particular element in the network reaches its limits and cannot carry any more electricity, it is 'congested'. Congestion limits are not only determined by the normal flow of electricity across that element itself, but also by the flow that would occur following a major contingency event occurring elsewhere in the network. For example, a trip of an element elsewhere in the system may cause additional electricity to flow in the first element, which it must be capable of carrying.

15 AEMO's Interconnector Quarterly Performance Reports are available on AEMO's website, www.aemo.com.au, viewed 3 August 2016.

16 See also AEMC, *Congestion Management Review*, 2008, p50.

Congestion is a normal feature of power systems and occurs because there are physical limits, needed to maintain the power system in a secure operating state, such as:

- the capacity of elements in the network;
- thermal limits: these refer to the heating of a transmission element. The heating of transmission lines, for example, increases as more power is sent across them, which causes the lines to sag closer to the ground. Thermal limits are used for managing the power flow on a transmission element so that it does not exceed a certain rating; and
- stability limits: these include limits to keep the NEM generating units operating synchronously and in a stable manner (for example within design tolerances for voltage), and transmission elements operating in a stable manner.

Violating these limits may damage equipment, cause dangerous situations for the general public and may ultimately lead to supply interruptions.

Constraints in transmission infrastructure further removed from regional boundaries can impact on the ability of electricity to flow across regional boundaries. The potential for inter-regional trade is therefore not only influenced by the limits of the interconnector capacity itself, but also by constraints occurring in parts of the network further removed from the actual interconnector infrastructure. In other words: *intra*-regional transmission constraints can impact on *inter*-regional transmission flows.

## A.4 Constraints and the dispatch process

The dispatch process determines which generators will be required to generate electricity, and how much they will be required to generate in order to meet demand. This process is managed by AEMO. To that end, AEMO operates the national electricity market dispatch engine (NEMDE), a computer program designed to optimise dispatch decisions.

NEMDE dispatches generation on a five-minute interval basis, taking into account a variety of parameters and variables. Among these are generator offers, but also the thermal, voltage and stability limits of the network. Within these parameters, NEMDE calculates the optimal market solution for dispatch. That is, the lowest cost solution for dispatch of generation in order to meet demand.

Network constraints affecting the network transfer capability are 'translated' for the purpose of operating NEMDE into 'constraint equations'. Each network constraint equation is a mathematical representation of the way in which different variables affect flows across particular transmission lines. A network constraint is thus a limitation imposed on the market dispatch process accounting for the physical restrictions necessary for secure operation of the system.

**Box A.1 Constraint equations**

The convention for network constraints used in NEMDE is to include terms that can be controlled (optimised) by AEMO through dispatch on the left hand side (LHS) of the equation, and terms that cannot be controlled by AEMO through the dispatch on the right hand side (RHS) of the equation.

Hence, generator output terms and interconnector flow terms tend to appear on the LHS, while terms relating to the limits of particular transmission elements tend to appear on the RHS.

For example, a constraint of the form:

$\alpha G + \beta IC \leq 500$

means the weighted dispatch of the generator (G) and interconnector (IC) cannot exceed 500 MW. The α and β represent the coefficients, or weights, that denote to what extent the G and IC contribute to the constraint.

All the relevant conventions for constraint building and constraint naming for the use of constraint equations in AEMO's market systems are published in AEMO's *Constraint Formulation Guidelines* and *Constraint Naming Guidelines*.

Regions of the NEM are identified through the use of single character identifiers (for example: Queensland = Q; New South Wales is N, and so on). Interconnectors are identified as 'I'. Similarly, various substations have their own identifiers. For example, substation Buronga = BU; substation Darlington Point is DP; Mount Beauty = MB, and so on. Transmission lines between substations are noted by the use of the grouped IDs of the substations between which the line runs. For example: the ID 'BUDP' for example refers to the Buronga-Darlington Point 220 kV line.

When there are no outages in a region (a 'system normal' condition), this is identified as 'NIL'. Hence, N-NIL means: New South Wales region: system normal.

Similarly, there are naming conventions for the causes of constraints, such as single and multiple plant outages and constraints caused by thermal (noted by an '>'), voltage (noted by an '^') and stability limits (noted by an ':').

Constraint sets are a group of constraint equations required to identify a particular network condition.

As a general rule, constraint set equations names identify:

- the region where the constraint exists or the two regions for a interconnector limit ('region ID');
- the cause of the constraint ('cause ID');

- the system condition ('outage ID').

For example: I-BCDM_ONE means: outage of one Bulli Creek - Dumaresq 330 kV line. And: Q^NIL_GC means: Gold Coast system normal voltage stability limit.

The naming guideline for inter-regional or fully co-optimised constraints mainly affecting an interconnector for example is:

'from region ID' 'cause ID(s)' 'to region ID' _ ' outage ID' _ ' unique ID (if necessary)'

Hence, the equation Q:N_ARTW_4 means: Qld to NSW transient stability, Armidale to Tamworth line outage, inter-regional.

When economic dispatch is limited, that is where AEMO cannot dispatch the lowest bid priced generation because of network constraints, a constraint is said to be 'binding'.

Information about constraints feeds into the planning process, as TNSPs will need to assess the costs and benefits of addressing constraints. Where it is economic to do so, constraints can be addressed by either:

- augmentations to the transmission infrastructure, called 'network options'.[17]
- solutions such as demand-side management and network support control ancillary services,[18] which may reduce the strain on transmission infrastructure elements during certain periods, thereby assisting in maintaining operation of this infrastructure within its physical limits. These solutions are termed 'non-network options'.

## A.5 The effect of network constraints

Constraints undermine the benefits of interconnection. In particular, congestion in the network can result in certain sources of generation being 'constrained off' from other parts of the network. This may result in the dispatch of higher-priced generation than would not have been the case without the constraint.

In theory, congestion may be eliminated if sufficient money was spent on expanding, or upgrading transmission network infrastructure. However, the cost of doing this may outweigh the costs incurred from the congestion itself. In this sense, congestion occurs not only because of the network’s physical limitations, but also because of economic

17 An augmentation refers to work undertaken to enlarge the system (extension) or to increase its capacity to transmit electricity (upgrade).

18 Network control ancillary services can include generation or automatic load reduction to relieve network overload following a contingency.

considerations of net costs and benefits. In other words, some level of congestion is likely to be economically efficient.[19]

Network congestion also impacts on the ability of NEM participants to manage risks associated with inter-regional trade.

**Box A.2 Congestion and inter-regional settlement residues[20]**

Participants in the NEM who engage in inter-regional trade are exposed to the risk of divergence between regional reference prices in the NEM. This occurs because generators receive the spot price in the region where they operate, while retailers pay the spot price in the region where the electricity purchased is effectively consumed. Because of differences in the regional reference prices, which may be the result of network congestion, there can be a misalignment between the amounts payable and received, causing a financial risk for participants conducting an inter-regional transaction.

NEM participants manage some part of this risk by buying inter-regional settlement residues. Inter-regional settlement residues arise from the transfer of electricity through regulated interconnectors only. These residues are a pool of funds equal to the difference in the regional reference price between two regions in the NEM multiplied by the quantity of electricity flowing over an interconnector between those two regions. As electricity normally flows from lower priced regions to higher priced regions, these funds usually represent a positive amount. These funds are held by AEMO via the NEM settlement process. AEMO then auctions off these residues among interested NEM participants. These auctions provide eligible NEM participants access to the inter-regional settlements residue by enabling them to bid in advance for the right to an uncertain future revenue stream.

As noted above, the methodology for inter-regional settlement residues does not apply in respect of interconnectors which provide market network services. That is, it does not apply to Basslink, which is not a regulated interconnector. For Basslink, inter-regional revenues represent the difference between the value of energy in Victoria and the value of that energy once it has been transferred to Tasmania, or vice versa for flows from Tasmania to Victoria. This difference in value is primarily due to the price difference between the two regions and represents a revenue stream for Basslink. These price differences can also be due to the applications of inter-regional transmission constraints or the dynamic loss factors that apply between the two regions.

Network congestion may, however, give rise to counter-price flows, where electricity flows from a high-priced region to a low-priced region. Under these circumstances, the amount payable by AEMO to the generators in the exporting region (the high-price region) is not covered by amounts received from retailers

19 See AEMC, *Congestion Management Review*, 2008, p51.

20 AEMO, Guide to the settlements residue auction, 22 July 2014, p6.

in the importing region (the low-priced region). As a result, inter-regional settlement residues can be negative. The cost of funding these negative settlement residues is ultimately borne by consumers in the importing region.[21]

21 The proceeds of settlement residue auctions are paid by AEMO to TNSPS, and are subsequently used to reduce the network service fees charged to TNSP customers. Negative settlement residues reduce the proceeds of the auction and hence the amounts payable to TNSPs. TNSPs then recover these expenses through higher network service fees.

# B Planning reports considered by the AEMC

This Appendix provides information on the planning reports the AEMC has considered to examine whether TNSPs are adequately examining inter-regional constraints.

## B.1 National Transmission Network Development Plans for 2015 and 2016

This section sets out:

- general information on the National Transmission Network Development Plan (NTNDP); and
- a summary of the forecast scenarios used in the NTNDP for 2016. This information is relevant to the analysis that follows in Appendices C to H.

### B.1.1 General information

The NTNDP is concerned with modelling the development of the critical national transmission flow paths. That is, those areas of the transmission network connecting major generation or demand centres.

The NTNDP seeks to influence transmission investment by:

- providing a national focus on market benefits and transmission augmentations to support an efficient power system;
- proposing plausible future scenarios and exploring their electricity supply industry impacts, with an emphasis on identifying national transmission network constraints under those scenarios, and providing a consistent plan that identifies their transmission network needs; and
- identifying network needs early to increase the time available to identify non-network alternatives, including demand-side and generation options.

For planning purposes, the NTNDP divides the NEM transmission network into sixteen zones, referred to as 'NTNDP zones'. These zones capture differences in generation technology capabilities, such as wind capacity, that exist within the NEM region and areas of potential congestion in the transmission corridors or flow paths linking the transmission zones.

Figure B.1 identifies the transmission zones and the main flow paths between these zones.

**Figure B.1 National transmission zones and flow paths**


| NTNDP zone | Zone abbreviation |
|---|---|
| North Queensland | NQ |
| Central Queensland | CQ |
| South West Queensland | SWQ |
| South East Queensland | SEQ |
| Northern New South Wales | NNS |
| Central New South Wales | NCEN |
| Canberra | CAN |
| South West New South Wales | SWNSW |
| Latrobe Valley | LV |
| Melbourne | MEL |
| Country Victoria | CVIC |
| Northern Victoria | NVIC |
| Adelaide | ADE |
| Northern South Australia | NSA |
| South East South Australia | SESA |
| Tasmania | TAS |

Source: AEMO, *Planning methodology and input assumptions*, 30 January 2014, p5.

### B.1.2 NTNDP for 2016

As required by the NER, the AEMC considers the NTNDP for the current and previous year when considering whether to exercise the LRPP.[22] The relevant NTNDPs are therefore the NTNDP for 2015 which was published by AEMO in December 2014, and the NTNDP for 2016 which was published by AEMO in November 2015. While both NTNDPs were considered, the Commission has given significantly more weight to the NTNDP for 2016 in its consideration of whether to exercise the LRPP as the investment needs identified by AEMO in this report are based on more recent electricity demand and supply forecasts.

In the NTNDP for 2016, AEMO developed scenarios and sensitivities that reflect changes likely to impact the use, operation and development of transmission networks. These scenarios and sensitivities are the basis for the forecasting of constraints on the transmission network over AEMO's forecast period. No new coal-fired generation is assumed to be installed across all scenarios and sensitivities.

22 NER clause 5.22(f)(2).

In the NTNDP for 2016, AEMO considered that two scenarios for forecasting constraints were credible:[23]

- **Gradual Evolution:** where consumer demand growth continues in line with medium forecasts and there is gradual penetration of rooftop solar PV and residential electricity storage, designed to reflect a future where there are no major cost reductions or policy incentives to promote uptake of new technology; and

- **Rapid Transformation:** where consumer demand continues on a low trajectory and there is a high penetration of embedded technologies, including: residential solar PV at saturation; 40 per cent of households with residential battery storage; and 20 per cent of households with electric vehicles. This scenario is designed to reflect a future where embedded technologies experience rapid uptake, driven possibly by significant cost reductions and new policy initiatives.

Sensitivities for each scenario were developed to reflect the possibility of PV becoming more cost-competitive with wind generation. The two scenarios, together with sensitivities, are set out below in Table B.1

**Table B.1 Scenarios and sensitivities in the NTNDP for 2016**

| Scenario | Case/Sensitivity | Consumer demand | Rooftop PV forecast | Battery storage forecast | Electric vehicle forecast |
|---|---|---|---|---|---|
| Gradual Evolution | Base scenario | In line with medium forecast | Gradual penetration (21 GW total residential and commercial by 2035) | 8GWh by 2035 | N/A |
| | Sensitivity – lower large-scale solar costs. | | | | |
| Rapid Transformation | Base scenario | Continues on a low trajectory | High penetration (33 GW total residential and commercial by 2035) | 19GWh by 2035 (40 per cent of households) | 20 per cent of households (approximately 2 million vehicles) |
| | Sensitivity – lower-large scale solar costs and a higher amount of large-scale renewable generation. | | | | |

Source: AEMO, *National Transmission Network Development Plan*, November 2015, p10.

More detail on the planning methodology and input assumptions used in the NTNDP for 2016 are published in AEMO's NTNDP for 2016.[24]

23 AEMO, *National Transmission Network Development Plan*, November 2015, p10.

24 AEMO, *National Transmission Network Development Plan*, November 2015, p10.

## B.2 The NEM constraint report for 2015

The NEM constraint report published annually by AEMO contains details about constraint equation performance in the preceding calendar year.[25] It also provides information on the drivers of constraint equation changes, analysis of binding and violating constraint equations, market impact of constraint equations and those equations that set interconnector limits.

As the constraint report is published after the NTNDP, TNSPs have had the ability to use or consider this information to inform their annual planning reports. The relevant NEM constraint report for the 2016 LRPP review is the NEM constraint report for 2015 published by AEMO in May 2016.[26]

For the purpose of consideration of the LRPP, the Commission has analysed the 'system normal'[27] constraints that were most binding on interconnector limits, in terms of the number of hours, in each direction. The top three binding constraints in each direction for each interconnector are outlined in the analysis on the individual interconnectors in Appendices C to H of this report.

In addition to those equations setting interconnector limits, constraints can also be listed according to their market impact. The market impact value seeks to quantify, in dollar value, the impact of a particular constraint.[28] The top three market impacts for each interconnector from the NEM constraint report for 2015 in each direction is also outlined in the analysis on the individual interconnectors in Appendices C to H of this report.

It is important to note that the number of hours a constraint may bind on an interconnector may not necessarily correlate with its market impact. Further, given the interconnectedness of the transmission system, often a binding constraint on an interconnector will also appear in the constraint equations of other interconnectors. For example, this occurs in Victoria where the system normal constraint to avoid overloading the South Morang 500/330 kV (F2) transformer for no contingencies, also appears in the constraint equations for the Heywood, Basslink, Murraylink, Victoria–New South Wales and the Queensland-New South Wales interconnectors.

25 See for example, AEMO, *NEM constraint report 2015*, May 2015.

26 AEMO, *NEM constraint report 2015*, May 2015.

27 System normal constraints do not include constraints caused by outages of transmission elements or frequency control ancillary service requirements.

28 The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

## B.3 2016 transmission annual planning reports

By 1 July each year, each TNSP must publish an annual planning report.[29] This report must set out the outcomes of a TNSPs annual planning review which a TNSP is required to conduct under the NER.[30] The annual planning review involves a TNSP analysing the expected future operation of its transmission network, taking account of forecast future demand and generation, demand-side and transmission developments and other relevant data.[31] In addition, a TNSP must consider the potential for network augmentations or non-network alternatives to augmentations when conducting an annual planning review.[32]

Importantly, TNSPs are also required to take the most recent NTNDP into account when conducting their annual planning review.[33] In particular, when a TNSP proposes augmentations to the network, it must explain in its annual planning report how the proposed augmentations relate to the most recent NTNDP and the development strategies for current or potential national transmission flow paths specified in the NTNDP.[34] This provides coordination between the planning priorities identified by AEMO in the NTNDP regarding inter-regional flow paths and the planning activities undertaken by TNSPs for each jurisdiction. In addition to inter-regional flow paths, the TNSPs will typically also consider upgrades that primarily affect transmission flow paths within their regions.

The minimum forward planning period for the annual planning review and therefore that covered by the annual planning report is ten years.[35] The relevant transmission annual planning reports for the 2016 LRPP review are those published in 2016.

## B.4 Regulatory investment test reports

The NER require that TNSPs must apply a regulatory investment test for transmission (RIT-T) for any augmentation projects with an estimated cost of more than $6 million.[36]

The purpose of the RIT-T to identify the transmission investment option that maximises the net economic benefit to all those who produce, consume and transport

29 NER clause 5.12.2(a).

30 NER clause 5.12.1(b).

31 NER clause 5.12.1(a).

32 NER clause 5.12.1(b)(4).

33 NER clause 5.12.1(b)(3).

34 NER clause 5.12.2(c)(6).

35 NER clause 5.12.1(c).

36 The application of the regulatory investment test for transmission is also subject to a number of exceptions under clause 5.16.3(a) of the NER. The threshold increased to $6 million on 1 January 2016 as a result of a cost thresholds review final determination made by the Australian Energy Regulator on 5 November 2015.

electricity in the market, after performing cost-benefit analysis on a number of credible options.[37] The NER define a 'credible option' as an option or group of options that:

- address the identified need;
- is, or are, commercially and technically feasible; and
- can be implemented in sufficient time to meet the identified need.[38]

The costs associated with options for transmission augmentation must be weighed against the benefits they are likely to bring to the market. Investments may be undertaken to either meet reliability standards or to deliver a net market benefit, for example, economic expansion.[39]

The NER also require the regulatory investment test to consider a number of classes of market benefits that could be delivered by each credible option, such as:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in the costs for parties, other than the transmission proponent, due to:
  - differences in the timing of new plant;
  - differences in capital costs; and
  - differences in operating and maintenance costs;
- changes in network losses;
- changes in ancillary service costs; and
- competition benefits.[40]

The procedure that a proponent must follow in conducting a regulatory investment test is also outlined in the NER.[41] Following completion of the regulatory investment procedure a project assessment conclusions report is published.

37 NER clause 5.16.1.

38 NER clause 5.15.2.

39 NER clause 5.16.1(c).

40 NER clause 5.16.1(c)(4).

41 NER clause 5.16.4.

# C Review of the Queensland–New South Wales interconnector

> All transmission network constraints on the Queensland–New South Wales interconnector are being addressed by the relevant TNSPs in their transmission annual planning reports. Similarly, all network constraints in the main transmission corridors around the interconnector in Queensland and NSW are being addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning power.

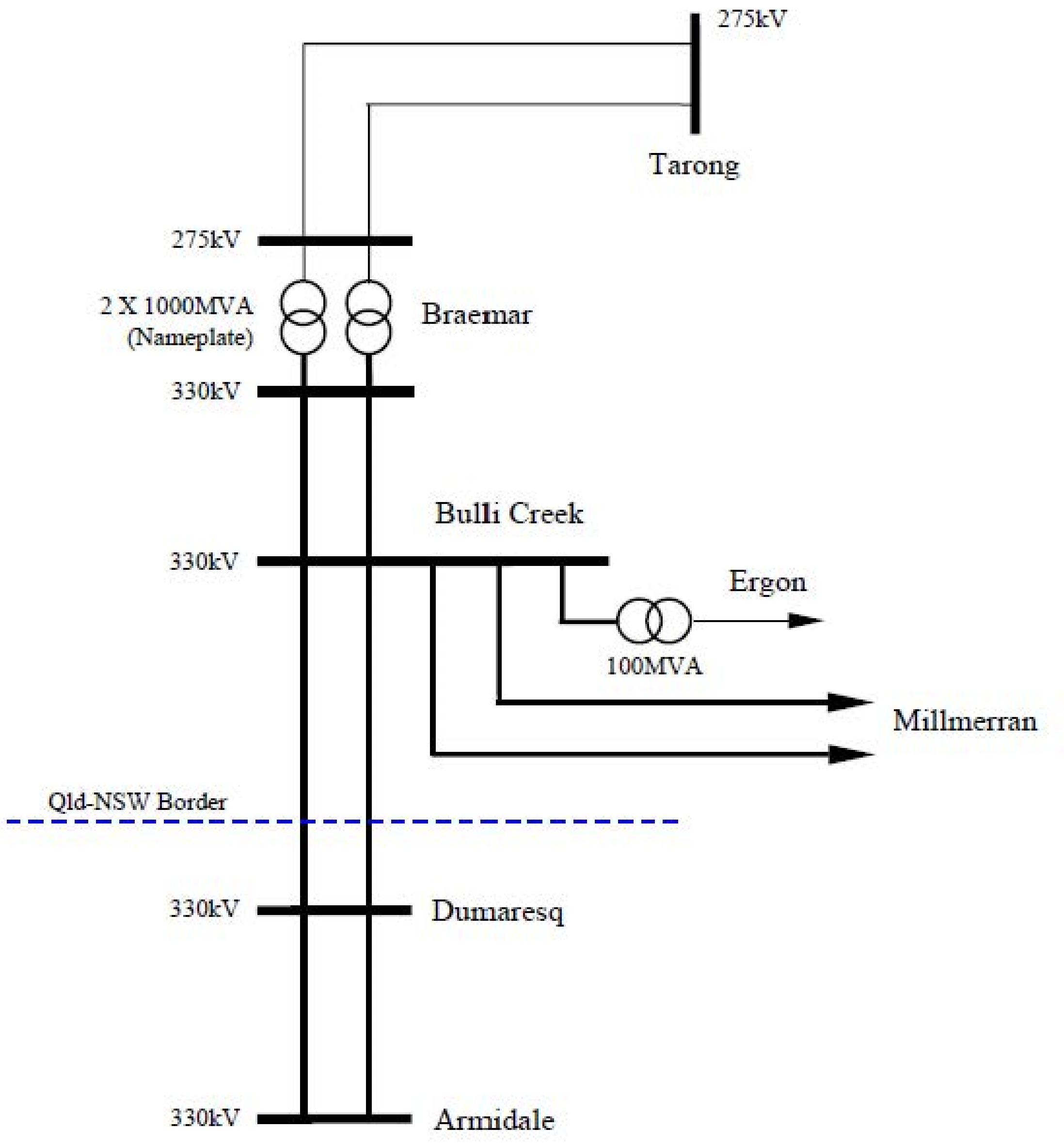
This section provides the Commission's analysis of whether there are any constraints on or around the Qld-NSW interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. It includes:

- an overview of the Queensland–New South Wales interconnector;
- a review of the binding constraint equations that most often set the limits on this interconnector from AEMO's NEM constraint report for 2015;
- a review of the emerging transmission network constraints affecting this interconnector from the NTNDP for 2016, published in November 2015;
- a review of TransGrid and Powerlink's 2016 transmission annual planning reports on projects to address limitations to the interconnector and the main transmission corridors; and
- a summary of the projects identified to reduce transmission network constraints.

## C.1 Overview of Queensland–New South Wales interconnector

The Queensland–New South Wales interconnector (QNI) connects the South West Queensland zone with the North NSW zone. It runs between Bulli Creek in Queensland and Dumaresq in NSW as set out in Figure C.1.

**Figure C.1 Queensland–New South Wales interconnector**




Source: Powerlink and TransGrid, Benefits of upgrading the capacity of the QNI, March 2004.

The South West Queensland zone has the highest installed generating capacity in the Queensland region. The Northern NSW zone has no major generation sources, so the zone is a net importer and a corridor of power flows between Queensland (both QNI and Terranora) and the rest of NSW.

The flow on QNI is normally from Queensland into NSW. However, at times of high generation in NSW or low generation in Queensland, the flow can reverse and go from

NSW to Queensland. Due to their close electrical proximity to the NSW side, both QNI and Terranora often appear on the left hand side of constraint equations.[42]

## C.2 Findings from the NEM constraint report for 2015

The transfer of electricity from NSW to Queensland is mainly limited by the system normal constraint equations for the voltage collapse on loss of the largest Queensland generating unit (Kogan Creek) and the trip of the Liddell to Muswellbrook 330 kV line in NSW.

Transfer from Queensland to NSW is normally limited by the transient stability limits for a fault on a Bulli Creek to Dumaresq line or frequency control ancillary services requirements for outages of lines between Bulli Creek and Liddell.

In 2015, electricity through the QNI was mainly transferred from Queensland to NSW, albeit at lower levels between 200 and 300 MW. The most constrained export flows from Queensland into NSW were at levels between 1,000 and 1,010 MW.[43]

The top three most binding system normal constraints that affected flows on QNI in both directions for 2015 are outlined in Table C.1.

**Table C.1 Binding constraint equations setting the QNI limits in 2015 (system normal)**

| NSW to Queensland limits | | | |
|---|---|---|---|
| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
| N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B<br><br>(This constraint was also identified on the Terranora (Directlink) interconnector). | 176.0 | To avoid voltage collapse for the loss of the largest Queensland generator.<br><br>This voltage collapse limit is split into seven constraint equations to co-optimise with each of the six largest generators in Queensland. Overall N^^Q_NIL_B1 (for trip of Kogan Creek) binds for the most | $1,101,202 (number one in top ten constraints with a market impact in New South Wales). |

42 This means that QNI and Terranora flows can be limited by the same constraint, in which case the NEM dispatch engine (NEMDE) does a trade-off between flows on QNI and Terranora when this constraint binds.

43 AEMO, *NEM constraint report 2015*, May 2016, p22.

| | | | |
|---|---|---|---|
| | | number of intervals. | |
| N>>N-NIL__3_OPENED<br><br>(This constraint was also identified on the Terranora (Directlink) interconnector). | 25.7 | To avoid overloading Liddell to Muswellbrook 330 kV line on trip of Liddell to Tamworth 330 kV line. | $298,577 (number two in top ten constraints with a market impact in New South Wales). |
| N^Q_NIL_A | 3.7 | To avoid voltage collapse on loss of Liddell to Muswellbrook 330 kV line. | $3,659 (number seven in top ten constraints with a market impact in New South Wales). |
| **Queensland to NSW limits** | | | |
| Q:N_NIL_AR_2L-G | 377.3 | To avoid transient instability for a two line to ground fault at Armidale. | $30,804 (number four in top ten constraints with a market impact in Queensland). |
| V::N_NILxxx<br><br>(This constraint was also identified on the Vic-NSW, Heywood, Murraylink and Basslink interconnectors). | 25.2 | To prevent transient instability for fault and trip of a Hazelwood to South Morang 500 kV line. | $117,936 (number seven in top ten constraints with a market impact in Victoria). |
| N>N-NIL_8C_8E | 0.1 | To avoid overload on Dumaresq to Armidale (8C) on trip of Dumaresq to Armidale (8E) line. | $69 (number nine in the top ten constraints with a market impact in NSW). |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2015 and *NEM constraint report 2015 supplementary data*, May 2015.

## C.3 Network constraints affecting the Queensland–New South Wales interconnector

### C.3.1 Findings from the NTNDP for 2016

The NTNDP for 2016 identified one constraint in NSW around the QNI interconnector.

AEMO identified the potential economic constraint as being between Tamworth and Muswellbrook/Liddell during the forecast period to 2034-35. AEMO considers that this constraint will eventuate with high wind generation in the northern NSW zone when power flows from this zone to the NSW central zone and under all scenarios and sensitivities.[44]

The NTNDP for 2016 did not identify any constraints in the transmission corridor leading to the QNI in Queensland.

### C.3.2 Findings from Powerlink's 2016 transmission annual planning report for Queensland

Consistent with the NTNDP for 2016, Powerlink has not identified any emerging reliability or potential economic dispatch limitations across the main transmission network linking NTNDP zones within the Queensland region. As a result, Powerlink has not identified any projects in Queensland around the QNI.

### C.3.3 Findings from TransGrid's 2015 New South Wales transmission annual planning report

TransGrid has identified a number of projects which are contingent upon augmentation of the Queensland-New South Wales interconnector. These projects are:[45]

- Upgrade of the Tamworth and Armidale 330 kV switchyards - the establishment of QNI and the connection of an SVC at Armidale has changed the utilisation of the substations from serving local load to being critical switching stations and, in the case of Armidale, voltage support for high transfers on QNI.
- Upgrade of the Hunter Valley–Tamworth–Armidale 330 kV system capacity - capacity limitations may arise from increased power flows to and from Queensland and increased generation developments (gas, solar and wind) in the Northern NSW region. This constraint was identified by AEMO in its NTNDP for 2016 as discussed in section 3.3.1.
- Voltage control in the Northern NSW zone - the ability to maintain adequate voltage levels is the most constraining limitation on the NSW export capacity to Queensland. In particular, the ability to maintain adequate voltage levels at Tamworth, Armidale and Dumaresq is critical for inter-regional transfer.

The possible upgrade of the QNI was recently the subject of a RIT-T undertaken by TransGrid jointly with Powerlink. The outcome of the RIT-T which concluded in November 2014 was that there were no credible options which demonstrated a clear net market benefit. In addition there was too much uncertainty around key input factors to which market benefits were sensitive.[46] In its transmission annual planning

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44 AEMO, *National Transmission Network Development Plan*, November 2015, p20.

45 TransGrid, *NSW transmission annual planning report*, pp57-58.

46 Powerlink and TransGrid, *Project assessment conclusions report, Development of the Queensland - NSW interconnector*, 13 November 2014, p7.

report TransGrid states that it intends to revisit an assessment of market benefits of upgrading QNI within five to ten years.[47]

## C.4 Summary of projects for identified network constraints

There are no forecast transmission network constraints on QNI, or in the transmission corridors around QNI in Queensland or NSW that are not being adequately addressed by the relevant TNSPs in their 2016 annual planning reports. Table C.2 provides a summary of identified constraints and projects being undertaken by TNSPs to deal with those constraints.

**Table C.2 Summary of constraints relating to the QNI interconnector and how these are being addressed by the relevant TNSPs**

| Report limitation identified | Details of constraint identified | Project to address constraint | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint) | Relieve future constraints in the Northern NSW zone, in particular between Liddell and Tamworth, at times of high northward flows on the QNI interconnector. | Increase system capacity between Hunter Valley, Tamworth and Armidale (TransGrid). | Contingent on QNI being upgraded and new generation being connected in the Northern NSW zone. TransGrid have committed to undertaking a re-evaluation of the QNI upgrade with Powerlink. |

47 TransGrid, *NSW transmission annual planning report*, p57.

# D Review of Terranora (Directlink) interconnector

All constraints on Terranora are being adequately addressed by the relevant TNSP. Similarly, all network constraints in the main transmission corridors around Terranora in Queensland and NSW are being adequately addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning powers.

This section provides the Commission's analysis of whether there are any constraints on and around the Terranora interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. It includes:

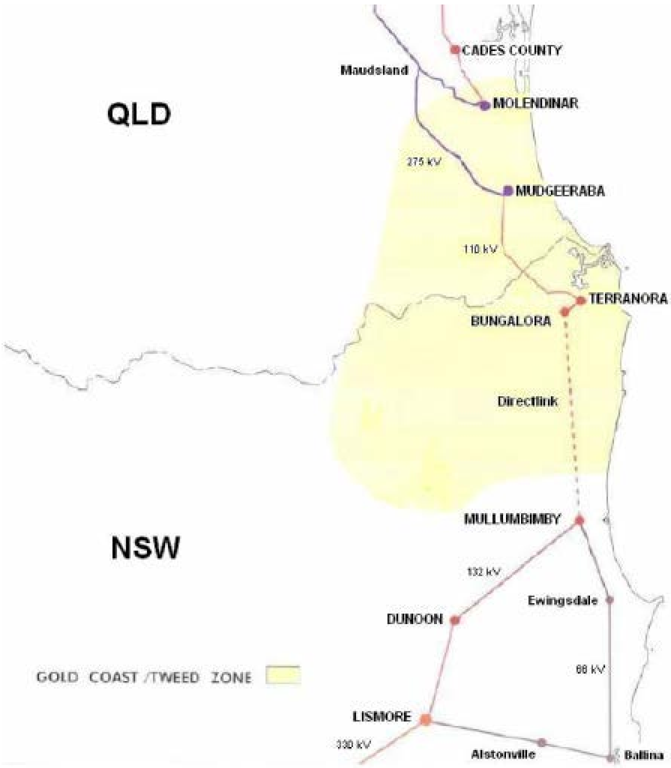
- an overview of the Terranora interconnector;
- a review of the binding constraint equations that most often set the limits on Terranora from AEMO's NEM constraint report for 2015;
- a review of the emerging transmission network constraints affecting the Terranora interconnector from the NTNDP for 2016 published by AEMO in November 2015;
- a review of Powerlink and TransGrid's 2016 transmission annual planning reports on projects to address constraints on Terranora and the main transmission corridors; and
- a summary of the projects identified to reduce transmission network constraints.

## D.1 Overview of Terranora

The Terranora interconnector comprises the two 110 kV lines from Terranora in NSW to Mudgeeraba in the South East Queensland zone as set out in Figure D.1. The controllable element is a 180 MW direct current link between Terranora and Mullumbimby (both in NSW), known as Directlink, which consists of three separate direct current lines.[48] Directlink was commissioned in 2000, forming the first connection between NSW and Queensland. The Terranora interconnector is owned by Energy Infrastructure Investments Pty Ltd.

48 Contrary to an alternating current interconnector, where the voltage and current are at any point sinusoidal, in a direct current interconnector, the power is transferred using constant voltage and current.

**Figure D.1 Terranora interconnector**




Source: APA Group, Directlink Network management plan, Directlink Joint Venture, May 2013

## D.2 Findings from the NEM constraint report for 2015

The majority of flows on this interconnector are towards NSW, so both the import and export values are negative unlike the other NEM interconnectors. It is usually constrained by thermal limits in the Northern NSW zone or the rate of change on Directlink.

The Terranora interconnector often appears along with the Queensland to NSW interconnector (QNI) on the left hand side of the stability constraint equations, so both interconnectors may be constrained at the same time.

Similar to 2014, most of the time that Terranora was restricted in 2015 was due to the outage of all three Directlink cables or outages of a single Directlink cable.[49] All three Directlink cables were out for 55.1 days in 2015 compared to 70.3 days in 2014.[50] [51]

The top three most binding, system normal, constraints in both directions for 2015 that affected flows on Terranora are listed in Table D.1. There were only two binding, system normal, constraints from Queensland to NSW.

49 AEMO, *NEM constraint report 2015*, May 2016, p21.

50 AEMO, *NEM constraint report 2015*, May 2016, p10.

51 The outage of all three Directlink cables bound for a total of 273.3 hours in 2015 and was one of the most binding interconnector constraints in the national electricity market. Similarly, instances where two Directlink cables were out equated to 251.4 days, or 39.9 binding hours in 2015.

### Table D.1 Binding constraint equations setting the Terranora limits in 2015 (system normal)

| **NSW to Queensland limits** | | | |
|---|---|---|---|
| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
| N^^Q_NIL_B1, 2, 3, 4, 5, 6 & N^Q_NIL_B<br><br>(This constraint is the same as that identified for QNI). | 60.3 | To avoid voltage collapse for the loss of the largest Queensland generator. | $1,101,202 (number two in the top ten constraints with largest market impact in NSW) |
| NQTE_ROC | 13.6 | Rate of change limit (80MW/5 minute) for Terranora interconnector. | $8,442 (does not appear in top ten constraints with a market impact in either Queensland or NSW) |
| N>>N-NIL__3_OPENED<br><br>(This constraint is the same as that identified for QNI). | 10.7 | To avoid voltage collapse on loss of Liddell to Muswellbrook (83) 330 kV line. | $298,577 (number two in the top ten constraints with largest market impact in NSW) |
| **Queensland to NSW limits** | | | |
| QNTE_ROC | 13.9 | Rate of Change (Qld to NSW) constraint (80 MW / 5 Min) for Terranora Interconnector. | $567 (number nine in top ten constraints with a market impact in Queensland) |
| N>N-NIL_MBDU | 0.3 | To avoid overloading Mullumbimby to Dunoon (9U6 or 9U7) 132 kV line on trip of the other Mullumbimby to Dunoon (9U7 or 9U6) 132 kV line. | $1 (number ten in top ten constraints with a market impact in NSW) |
| Q>NIL_MUTE_757 & Q>NIL_MUTE_758 | 0.1 | To avoid overloading a Mudgeeraba to Terranora (757 or 758) 110 kV line on no contingencies. | $5 number seven in top seven constraints in Queensland) |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2015 and *NEM constraint report 2015 supplementary data*, May 2015.

## D.3 Network constraints affecting Terranora

### D.3.1 Findings from the NTNDP for 2016

AEMO does not identify the need for increased power transfer capability between Queensland and NSW over the Terranora interconnector in the NTNDP for 2016. Therefore, the NTNDP for 2016 does not list augmentations of the Terranora interconnector. However, AEMO does identify the potential for future economic constraints in the northern NSW zone on the 132 kV network between Lismore and Dunoon/Mullumbimby. AEMO considers that this constraint will eventuate during high wind generation in the northern NSW zone when power flows from New South Wales to Queensland (through Directlink) and under all scenarios and sensitivities.[52]

The NTNDP for 2016 does not identify any constraints in the transmission corridor leading to Terranora in Queensland.

### D.3.2 Findings from Powerlink's 2016 transmission annual planning report for Queensland

Consistent with the NTNDP for 2016, Powerlink does not identify any emerging reliability or potential economic dispatch limitations across the main transmission network linking NTNDP zones within the Queensland region.

### D.3.3 Findings from TransGrid's 2016 New South Wales transmission annual planning report

TransGrid identifies a number of potential projects in northern NSW to address potential constraints on the transmission network in this area. TransGrid's transmission annual planning report does not reference the NTNDP for 2016's limitation on the 132 kV network between Lismore and Dunoon/Mullumbimby. However, AEMO advises that this constraint belongs to Essential Energy's distribution network area.[53] Essential Energy is aware of the constraint and is considering whether to identify and refer to it in its 2016 distribution annual planning report, subject to discussions with AEMO.[54] Essential Energy's 2016 distribution annual planning report will be published by the end of the year.[55]

52 AEMO, *National Transmission Network Development Plan*, November 2015, p20.

53 Based on advice given to the AEMC by AEMO staff on 15 August 2016.

54 Essential Energy confirmed this by email on 26 September 2016.

55 NER clause 5.13.2(a)(1)-(2).

## D.4 Summary of projects for identified network constraints

As there are no forecast transmission network constraints on Terranora, there are no constraints on this interconnector that are not being addressed. In addition, there are no network constraints in the main transmission corridors around Terranora in Queensland or New South Wales that are not being adequately addressed by the relevant TNSP. Table D.2 provides a summary of identified constraints and how these are being addressed by the relevant TNSPs.

**Table D.2 Summary of identified constraints relating to the Terranora interconnector and how these are being addressed**

| Report limitation identified | Details of constraint identified | Project to address constraint | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint). | Future constraints in Northern NSW zone, in particular between Lismore and Dunoon/ Mullumbimby, at times of high northward flows from wind generation from New South Wales to Queensland. | 132 kV network between Lismore and Dunoon/Mullumbimby belongs to Essential Energy. Essential Energy is aware of the constraint identified by AEMO and is considering whether to include it as part of its 2016 distribution annual planning report. | Essential Energy is considering whether to identify and refer to this constraint in its 2016 distribution annual planning report. |

# E Review of Victoria–New South Wales interconnector

All transmission network constraints on the Victoria-New South Wales interconnector are being addressed by the relevant TNSPs in their transmission annual planning reports. Similarly, all network constraints in the main transmission corridors around the interconnector in Victoria and NSW are being addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning powers.

This section provides the Commission's analysis of whether there are any constraints on and around the Victoria–New South Wales interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. This analysis includes:

- an overview of the Victoria-New South Wales interconnector;
- a review of the binding constraint equations that most often set the limits on this interconnector from AEMO's NEM constraint report for 2015;
- a review of the emerging transmission network constraints affecting the interconnector from the NTNDP for 2016 published by AEMO in November 2015;
- a review of TransGrid and AEMO's[56] 2016 transmission annual planning reports on projects to address constraints on the interconnector and the main transmission corridors; and
- a summary of projects planned to reduce identified transmission network constraints.

## E.1 Overview of the Victoria–New South Wales interconnector

NSW and Victoria are interconnected via the Victoria to New South Wales interconnector.

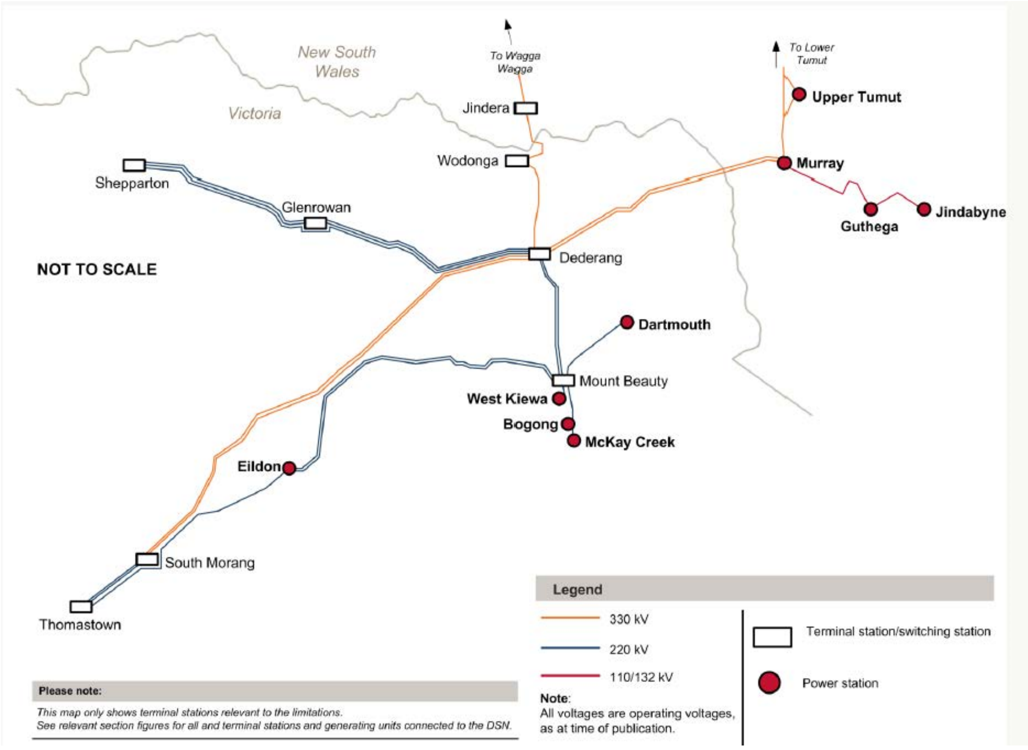
This interconnector comprises the 330 kV lines between Murray and Upper Tumut, Murray and Lower Tumut, and Jindera and Wodonga. These lines link the South West NSW zone with the Northern Victoria zone containing a large amount of hydroelectric generation. As such, they are part of the 'northern corridor' running between Murray (NSW) and South Morang (Victoria). This part of the interconnector is set out in Figure E.1.

In addition, the interconnector comprises the 220 kV line between Buronga and Red Cliffs connecting Victoria's north west, part of the Country Victoria zone, to the South

56 AEMO is responsible for the planning of the network in Victoria and is a TNSP for this purpose under the NER.

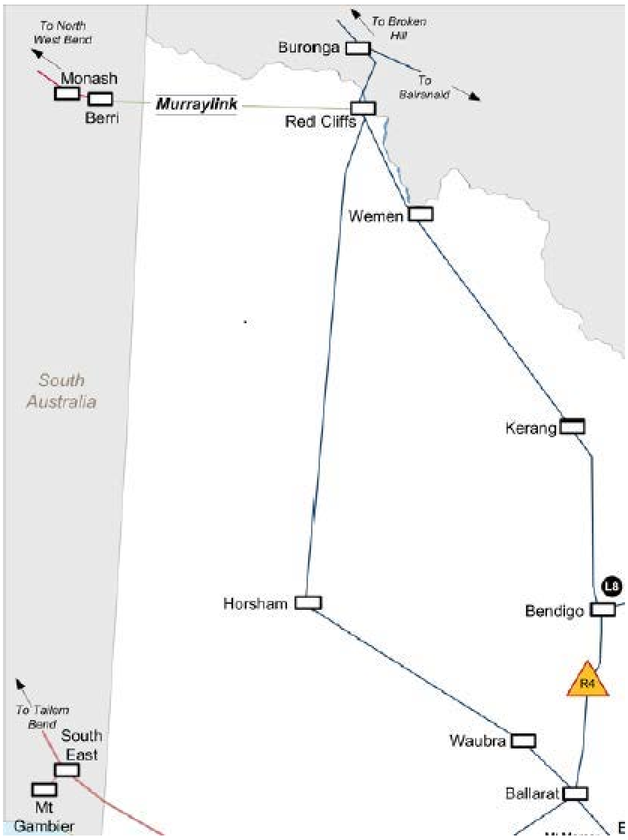
West NSW zone. This part of the network delivers supply to load centres in the Country Victoria zone such as Bendigo and Ballarat and also transfers power to South Australia via the Murraylink interconnector. This part of the indicator is set out in Figure E.2.

**Figure E.1 Victoria–New South Wales interconnector**




Source: AEMO, Victorian annual planning report, 2014, p33.

## Figure E.2 Victoria–New South Wales interconnector at Red Cliff




Source: AEMO, Victorian annual planning report, 2014, p31.

## E.2 Findings from the NEM constraint report for 2015

The Victoria–New South Wales interconnector may bind in either direction due to high demand in NSW or Victoria.

Transfer from Victoria to NSW is mainly limited by the thermal overload limits on the South Morang F2 transformer, the South Morang to Denderang 330 kV line, the Ballarat to Bendigo 220 kV line, or the Ballarat to Moorabool No. 1 220 kV line. The transient stability limit for a fault and trip of a Hazelwood to South Morang line may also set the limits.

Transfer from New South Wales to Victoria is mainly limited by voltage collapse for loss of the largest Victorian generator, or thermal overload limits on the Murray to Dederang 330 kV lines.[57]

In 2015, the hours at each flow level and the binding hours on the Victoria–New South Wales interconnector were similar to 2014. The main difference in 2015 (from 2014) was that the high flow levels into New South Wales were constrained for more hours.

57 AEMO, *NEM constraint report 2015*, May 2016, p24.

The top three most binding system normal constraints in both directions for 2015 that impacted on flows on the Victoria-New South Wales interconnector is listed in Table E.1.

**Table E.1 Binding constraint equations setting the Victoria–New South Wales interconnector limits in 2015 (system normal)**

| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
|---|---|---|---|
| **Victoria to NSW limits** | | | |
| V::N_NILxxx<br><br>(This constraint was also identified on the QLD-NSW, Heywood, Murraylink and Basslink interconnectors). | 1,045.5 | To prevent transient instability for fault and trip of a Hazelwood-South Morang 500 kV line. | $117,936 (number seven in top ten constraints with a market impact in Victoria). |
| V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P<br><br>(This constraint was also identified on the Heywood, Murraylink and Basslink interconnectors). | 873.1 | To avoid overloading the South Morang 500/330 kV (F2) transformer for no contingencies, for radial/parallel modes and unit 1 at Yallourn Power station on the 500 or 220 kV.<br><br>These constraint equations maintain flow on the South Morang F2 transformer below its continuous rating. | $97,998 (number ten in top ten constraints with a market impact in Victoria). |
| V>>SML_NIL_7A | 75.2 | To avoid overloading Ballarat North to Buangor 66 kV line on trip of the Ballarat to Waubra to Horsham 220 kV line. | $186,019 (number three in top ten constraints with a market impact in Victoria). |
| **NSW to Victoria limits** | | | |
| N^^V_NIL_1<br><br>(This constraint was also identified on the Murraylink interconnector). | 211.7 | To avoid voltage collapse for loss of the largest Victorian generating unit. | $94,201 (number three in top ten constraints with a market impact in NSW). |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2016 and *NEM constraint report 2015 supplementary data*, May 2016.

## E.3 Network constraints on the Victoria-New South Wales interconnector

### E.3.1 Findings from the NTNDP for 2016

The NTNDP for 2016 identifies several potential economic constraints relevant to the Victoria-New South Wales interconnector for the 2034-35 forecast period – one in NSW, and four in Victoria. These constraints include:[58]

- Transmission limitations between the Canberra NTNDP zone and the NSW Central NTNDP zone when there is high wind generation in Canberra and when power flows from South West NSW to Canberra (under all scenarios and sensitivities).
- Transmission limitations on South Morang's 500/330 kV transformer when there is high export from Victoria to NSW (under all scenarios and sensitivities).
- Transmission limitations on Dederang-South Morang 3330 kV circuits when there is high transfer between Victoria and NSW (either export or import; under all scenarios and sensitivities).
- Transmission limitations on Eildon-Thomastown 220 kV line when there is high transfer between Victoria and NSW (either export or import; under all scenarios and sensitivities).

### E.3.2 Findings from AEMO's 2016 Victorian transmission annual planning report

AEMO identified a number of relevant monitored transmission limitations and potential projects to address these NTNDP constraints in their 2016 Victorian transmission annual planning report (VAPR):

- The Dederang-South Morang 330 kV line loading limitation in Victoria's northern transmission corridor. The NTNDP for 2016 identifies this limitation as an inter-regional constraint when there is high transfer between Victoria and NSW.

58 AEMO, *National Transmission Network Development Plan*, November 2015, pp20-21.

AEMO identifies two possible solutions to this constraint:[59]

- uprating the two existing lines 82 °C (conductor temperature) operation and series compensation at an estimated cost of $16.2 million; or
- installing a new (third) 330 kV, 1,060 MVA single circuit line between Dederang and South Morang with 50% series compensation to match the existing lines, at an estimated cost of $234.6 million (excluding easement costs, and subject to obtaining the necessary easement).

- Another monitored limitation in Victoria's northern transmission corridor is the Eildon–Thomastown 220 kV line loading. AEMO also identifies this as an inter-regional constraint in the NTNDP for 2016 when there is higher transfer between Victoria and NSW (either export or import).

  AEMO identifies the possible network solutions as:[60]

  - installing a wind monitoring scheme at an estimated cost of $0.5 million; or
  - uprating the Eildon–Thomastown 220 kV line, including terminations to 75 °C operation, at an estimated cost of $42.8 million.

- A Victoria–New South Wales transfer limitation being monitored around Greater Melbourne and Geelong, triggered by additional export capability from Victoria to NSW due to surplus generation in Victoria.

  AEMO identifies a possible network solution through a new 500/330 kV transformer at South Morang, a Braking resistor at Loy Yang, and uprating of the South Morang–Dederang 330 kV lines. The total cost of these upgrades is expected to be approximately $72 million. The first two components are expected to be contestable.[61] This limitation was identified in the NTNDP for 2016 during periods of high Victorian export, and was identified as transmission limitations on South Morang's 500/330 kV transformer.

- The Kerang–Wemen–Red Cliffs 220 kV line loading in Regional Victoria (situated in the North West of Victoria). AEMO identifies two possible network solutions:

  - install an automatic load shedding control scheme to enable the use of five minute line rating; or
  - replace the existing Bendigo–Kerang–Wemen–Red Cliffs 220 kV line with a new double circuit 220 kV circuit line at an estimated cost of $581.4 million.

59 AEMO, *Victorian annual planning report*, June 2016, p36.

60 ibid.

61 ibid, p37.

### E.3.3 Findings from TransGrid's 2016 New South Wales transmission annual planning report

TransGrid indicates there may be net market benefits if parts of the network between Snowy and Sydney were to be uprated. Related to this, TransGrid are investigating a number of options relating to the lines between the Victoria–New South Wales interconnector and Sydney. In particular, potential projects relevant to the alleviation of inter-regional transmission constraints include:

1. Increased power transfer from the Snowy Mountains to the Yass and Canberra 330 kV lines through uprating of these lines. The need for increased power transfer could arise from:[62]

   — increased Snowy generation;

   — increased import from South Australia and Victoria at times of high demand in NSW and Queensland;

   — load growth in NSW and Queensland; and

   — decommissioning or reduction of coal-fired generation in NSW.

2. Increased power transfer on Yass/Canberra to the Bannaby/Marulan 330 kV lines. TransGrid identifies that the existing arrangements on these lines could be constrained under certain operating conditions if:[63]

   — the Snowy–Canberra network is upgraded and generation from Victoria and Snowy is transferred to NSW to the maximum capacity allowed by the upgrade; and

   — the present and future wind farms connected in the Southern NSW zone operate at or near their maximum capacities.

3. The Bannaby–Sydney West line 39 capacity could be exceeded if Gullen Range, Boco Rock and Taralga wind farms operate at their maximum capacity, even without any increase in the Snowy to Yass and Canberra capacity. Constraints in this part of the network would increase if other proposed generation comes to fruition. A number of other options are being investigated include:[64]

   — Capacity of Snowy to Yass and Canberra (as detailed in 1);

   — Capacity of Yass/Canberra to Bannaby/Marulan;

   — Capacity of Marulan/Kangaroo Valley to Dapto/Avon; and

   — Capacity of Bannaby/Avon/Dapto to Sydney.

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62 TransGrid, *NSW transmission annual planning report*, June 2016, p65.

63 ibid.

64 ibid, pp66-67.

TransGrid considers that any network development would be determined by detailed market modelling and there is no preferred network option at present.[65]

These potential projects may address NTNDP limitations identified by AEMO between the Canberra zone and the NSW Central zone when there is high wind generation in Canberra and when power flows from South West NSW to Canberra.

## E.4 Summary of projects for identified network constraints

There are no transmission network constraints on the Victoria–New South Wales interconnector or in the transmission corridors around this interconnector that are not being addressed by the relevant TNSPs in their transmission annual planning reports. Table E.2 provides a summary of constraints identified in relevant planning documents that may impact flows on the Victoria-New South Wales interconnector and how these constraints are being addressed by TransGrid and AEMO.

**Table E.2 Summary of transmission projects for identified network constraints impacting on the Victoria–New South Wales interconnector**

| Report limitation identified | Details of constraint identified | Project to address the identified need | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint). | Transmission limitations between Canberra and Central NSW zones. This is contingent upon high wind generation in the Canberra zone when power flows from the South West NSW zone to the Canberra zone. | A number of options relating to the lines between the VIC-NSW interconnector and Sydney are being investigated (TransGrid). | A potential project could be initiated although more detailed modelling would be required to help identify a preferred option. |
| NTNDP for 2016 (economic constraint). | Transmission limitation on South Morang 500/330 kV transformer. AEMO considers this is present when there is high export from Victoria to New South Wales. | A possible network solution through a new 500/330 kV transformer at South Morang, a Braking resistor at Loy Yang, and uprating of the South Morang–Dederang 330 kV lines (AEMO). | Projects identified but not committed as yet. AEMO is also monitoring changes to the Victoria generation mix that could increase the market benefits of this potential project, triggering a RIT-T. |

65 ibid, p67.

| Report limitation identified | Details of constraint identified | Project to address the identified need | Project status |
| --- | --- | --- | --- |
| NTNDP for 2016 (economic constraint). | Transmission limitations on Dederang-South Morang 330 kV circuits. AEMO considers that this constraint is present when there is high transfer between Victoria and New South Wales (export or import). | Two options are identified:<br><br>Uprating the two existing lines operation and series compensation (AEMO).<br><br>Installing a new (third) 330 kV, 1,060 MVA single circuit line between Dederang and South Morang with 50% series compensation to match the existing lines (AEMO). | Projects identified but not committed as yet. AEMO is monitoring changes to the Victoria generation mix that could increase the market benefits of these potential projects, triggering a RIT-T. |
| NTNDP for 2016 (economic constraint). | Transmission limitations on Eildon-Thomastown 220 kV line. AEMO considers that this constraint is present when there is high transfer between Victoria and New South Wales (export or import). | Two options are identified:<br><br>Installing a wind monitoring scheme (AEMO).<br><br>Uprating the Eildon–Thomastown 220 kV line, including terminations to 75 ºC operation (AEMO). | Projects are identified but not committed as yet. |

# F Review of Heywood interconnector

All transmission network constraints forecast on the Heywood interconnector are being addressed by the relevant TNSPs in their transmission annual planning reports. Similarly, all network constraints in the main transmission corridors around the interconnector in Victoria and South Australia are being addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning powers.

This section provides the Commission's analysis of whether there are any constraints on and around the Heywood interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. It includes:

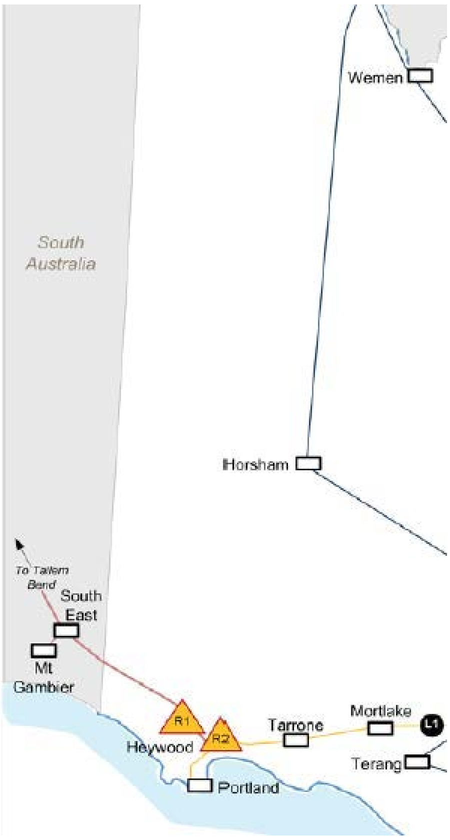
- an overview of the Heywood interconnector;
- a review of the binding constraint equations that most often set the limits on this interconnector from the NEM constraint report for 2015;
- a review of the emerging transmission network constraints affecting this interconnector from the NTNDP for 2016, published by AEMO in November 2015;
- a review of ElectraNet and AEMO's 2016 transmission annual planning reports on projects to address constraints on the interconnector and the main transmission corridors; and
- a summary of the projects identified to reduce transmission network constraints.

## F.1 Overview of the Heywood interconnector

The Heywood interconnector, set out in Figure F.1, is an alternating current connection between Heywood near Portland and the South East substation in South Australia in the state's south east. It was constructed in 1988 and features a 500/275 kV transformer at Heywood and operates at 275 kV into South Australia.

The wider Country Victoria zone includes load centres such as Geelong and Ballarat, and it links to the Melbourne and Northern Victoria zones. The transmission network in the South East South Australia zone supplies loads within this zone and transfers power towards Victoria. There is currently limited installed generation within this zone which mainly comes from wind energy.

**Figure F.1 Heywood interconnector**




Source: AEMO, Victorian annual planning report 2014, June 2014, p31.

Originally, most of the flows on the Heywood interconnector were from Victoria to South Australia. However, with the increasing number of wind farms in South Australia, the flow is now often from South Australia to Victoria. To alleviate constraints in this direction, in March 2010 the limit from South Australia to Victoria on the Heywood interconnector was increased from 300 to 460 MW and the combined Heywood and Murraylink limit was increased to 580 MW in January 2011.

In practice, power transfer capability between Victoria and South Australia via the Heywood interconnector is restricted by:

- the 460 MW limitation of transformer capacity at Heywood;
- voltage collapse constraints on the South Australia network following a South Australian generator trip; and
- thermal limitation on the underlying 132 kV transmission system in the South East Australia zone.

To further increase the capacity of the Heywood interconnector, ElectraNet and AEMO have conducted a regulatory test for investment. The results of this assessment are outlined in section F.3.1.

## F.2 Findings from the NEM constraint report for 2015

Along with other interconnectors to Victoria (Victoria–New South Wales, Basslink, and Murraylink), the Heywood interconnector appears in many of the Victorian constraint equations. This can lead to situations where many of these interconnectors can be limited due to the same network limitation.[66]

Flows are now most often restricted by thermal overloads on the Snuggery to Keith 132 kV line, transient stability limit for loss of the largest South Australian generator and, until December 2015, the Heywood 500/275 kV transformers. The Heywood transformer constraint equations were removed with commissioning of the third Heywood transformer.[67]

South Australia to Victoria transfers are mainly restricted by the thermal overload limits on the South East substation 275/132 kV transformers and the South Morang F2 transformer. The hours at each flow level on Heywood were very similar in 2015 to 2014 with the exception of more hours for high flows into South Australia (at the 450 MW flow level). There was also a corresponding increase in the binding hours at the 450 MW flow level compared to those of 2014.[68]

The top three most binding system normal constraints in both directions for 2014 that affected flows on the Heywood interconnector are listed in Table F.1.

**Table F.1 Binding constraint equations setting the Heywood interconnector limits in 2015 (system normal)**

| Victoria to South Australia limits | | | |
|---|---|---|---|
| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
| V::N_NILxxx<br><br>(This constraint was also identified on the QLD-NSW, Vic-NSW, Murraylink and Basslink interconnectors). | 748.7 | To prevent transient instability for fault and trip of a Hazelwood-South Morang 500 kV line.<br><br>AEMO notes that there are twelve constraint equations that make up the transient stability export limit from Victoria and all the binding results have been combined. | $117,936 (number seven in the top ten constraints with largest market impact in Victoria). |

66 AEMO, *NEM constraint report 2015*, May 2015, p25.

67 ibid.

68 ibid, p26.

| | | | |
|---|---|---|---|
| V>S_460 | 259.9 | VIC to SA on Heywood upper transfer limit of 460 MW. | $103,301 (number nine in the top ten constraints with largest market impact in Victoria). |
| V>>S_NIL_SETB_SGKH | 242.4 | To avoid overloading Snuggery to Keith 132 kV line on trip of a South East to Tailem Bend 275 kV line.<br><br>This will bind for high import into SA with high levels of generation from the wind farms and gas turbines in the south east. | $92,337 (number five in the top ten constraints with largest market impact in South Australia) |
| **South Australia to Victoria limits** | | | |
| V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P<br><br>(This constraint was also identified on the Victoria–New South Wales, Murraylink and Basslink interconnectors). | 872.3 | To avoid overloading the South Morang 500/330 kV (F2) transformer for no contingencies, for radial/parallel modes and Yallourn W1 on the 500 or 220 kV.<br><br>These constraint equations maintain flow on the South Morang F2 transformer below its continuous rating. | $97,998 (number ten in the top ten constraints with largest market impact in South Australia). |
| S>>V_NIL_SETX_SETX | 56.2 | To avoid overloading a South East 275/132 kV transformer on trip of the remaining South East 275/132 kV transformer.<br><br>This constraint equation binds when there is export from South Australia to Victoria and high generation from the wind farms and gas turbines in the south east of South Australia. | $68,441 (number seven in the top ten constraints with largest market impact in South Australia) |
| S>>SETX_NIL_SETX_1 | 21.7 | One South East 275/132kV | $57,760 (number eight in the top ten |

| | | | |
|---|---|---|---|
| | | transformer out of service, avoid overloading of other South East 132/275kV transformer on Nil trip. | constraints with largest market impact in South Australia) |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2015 and *NEM constraint report 2015 supplementary data*, May 2015.

## F.3 Network constraints on the Heywood interconnector

### F.3.1 Augmentation of the Heywood interconnector

Following the conclusion of a RIT-T by AEMO and ElectraNet, an upgrade of the Heywood interconnector was undertaken. This commenced in July 2013.[69] The upgrade of the Heywood interconnector includes:

- a third 500/275 kV transformer at the Heywood 500 kV transmission terminal station, to be delivered by AEMO and AusNet Services;
- series compensation of the two South East to Tailem Bend 275 kV lines;
- reconfiguration of substation assets and the existing 132 kV transmission system to allow increased utilisation of transmission line thermal ratings along the 275 kV interconnector; and
- South East 275/132 kV transformer control scheme, subject to the voluntary participation of the relevant generator(s).

It is expected to have a material impact on inter-regional transfer as it will increase interconnector capability by about 40 per cent in both directions. The net market benefits of the upgrade are estimated at more than $190 million, in present value terms, over the life of the project with positive net benefits commencing from the first year of operation.

Initial service of the full upgrade was completed in August 2016.[70] ElectraNet identifies that additional available transfer capacity is to be released in stages following

69 ElectraNet, *Heywood Interconnector Upgrade: Response to AER Information Request*, January 2014, p7.

70 AEMO, *Update Inter-Regional Transfer Limit Variation - Heywood Interconnector, Market Notice 54666*, 5 August 2016.

inter-network testing.[71] Full commercial service of the Heywood interconnector upgrade is to be achieved by March 2017.[72]

### F.3.2 Findings from the NTNDP for 2016

The NTNDP for 2016 identifies two potential economic constraints that may impact on flows across the Heywood interconnector in the 2034-35 forecast period.[73]

The first constraint is identified along the Tailem Bend–Tungkillo transmission corridor. AEMO considers this constraint may occur due to new generation it forecasts east of Adelaide or at times of high import from Victoria. AEMO identifies that this is expected to occur in the Rapid Transformation scenario (both the base scenario and sensitivity scenario) as outlined in Table B.1.[74]

AEMO also identifies a limitation on the Northern South Australia-Adelaide 275 kV corridor as a potential economic constraint (applies under the Gradual Evolution scenario in both the base and sensitivity case).

AEMO does not identify any inter-regional constraints within the Victorian transmission corridor leading up to the Heywood interconnector in the NTNDP for 2016.

### F.3.3 Findings from the AEMO's 2016 Victorian transmission annual planning report

Consistent with forecasts in the NTNDP for 2016, AEMO does not identify any projects in the transmission corridors in Victoria around the Heywood interconnector in their 2016 Victorian annual planning report.

### F.3.4 Findings from ElectraNet's 2016 transmission annual planning report

ElectraNet considers as part of its planning process three scenarios:[75]

- a base scenario which was ElectraNet's central planning scenario (the base scenario);
- a scenario which considers a number of potential future mining loads (the SA mining growth scenario); and
- a scenario that represents an extreme yet possible future expansion of SA wind generation (the SA renewable generation expansion planning scenario).

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71 ElectraNet, *South Australian transmission planning report*, June 2016, p46.

72 AEMO, *Victoria-South Australia (Heywood) Interconnector Upgrade: Test Program for Inter-network Tests*, November 2015, p7.

73 AEMO, *National Transmission Network Development Plan*, November 2015, p20.

74 AEMO, *National Transmission Network Development Plan*, November 2015, p20.

ElectraNet identifies in its 2016 transmission planning report several projects that may allow increased inter-regional transmission flows along the Heywood interconnector.

There is a completed project which followed the Heywood interconnector upgrade this year. It involves uprating the Tailem Bend to Tungkillo 275 kV line and the Tailem Bend to Mobilong 132 kV line from 80°C design clearances to 100°C design clearances. This project will increase the transfer capacity of lines that are forecast to, at times, constrain the Heywood interconnector following its upgrade in July 2016, enabling higher transfers across the Tailem Bend to Tungkillo corridor by about 132 MVA.[76] While increased ratings have been released for the Tailem Bend to Tungkillo 275 kV line, minor works are required to be finalised before improved ratings can be released for Tailem Bend to Mobilong 132 kV line.[77]

This project addresses the Tailem Bend–Tungkillo transmission corridor limitation economic constraint identified in the NTNDP for 2016. The estimated cost is less than $5 million.[78]

ElectraNet addresses the potential economic constraint on the Northern South Australia-Adelaide 275 kV corridor by identifying the following potential projects, including:

- applying dynamic line ratings to the Davenport to Robertstown 275 kV lines. The timing for the project is identified as within ten years, with an estimated cost of less than $5 million and is subject to the demonstration of market benefits. It is also contingent upon the SA renewable generation expansion planning scenario.[79]

- rebuilding Davenport–Brinkworth–Para 275 kV as a high capacity 275 kV AC double circuit line with twin conductors. This project would take up to 7 years to deliver, including 1-2 years to undertake a RIT-T and 5 years for easement acquisition, detailed design and delivery.[80]

- strengthening the Mid North 275 kV network through various line uprating and application of dynamic line ratings depending on generator developments. The timing for this project is 2 to 3 years.[81]

- tie Davenport to Robertstown 275 kV at Belalie Substation. This project would take up to 4 years, including 1-2 years to undertake a RIT-T and 2 years detailed design and delivery.[82]

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75 ElectraNet, *South Australian transmission annual planning report*, June 2016, pp60-61.

76 ibid, p64.

77 Based upon advice provided by ElectraNet to the AEMC on 15 September 2016.

78 ibid.

79 ibid, p71.

80 ibid, p36.

81 ibid.

82 ibid.

ElectraNet identifies two projects that are subject to demonstration of net market benefits that would have an impact on inter-regional transmission flows under the SA renewable generation expansion planning scenario. These projects are along its transmission corridor leading to the Heywood interconnector. These include:[83]

- applying dynamic ratings on the 275 kV lines in this line corridor would increase their available transfer at times of high wind generation. This would increase the export capacity of the Heywood interconnector at the times when it would be most needed. The cost of the project is estimated at less than $5 million and the timing is 2018-2023; and
- stringing a vacant circuit between Tungkillo to Tailem Bend 275 kV circuit and install dynamic reactive support at Tailem Bend. The cost is estimated at $25-50 million. There is currently no timing associated with this potential investment.

## F.4 Summary of projects for identified network constraints

There are no transmission network constraints on the Heywood interconnector, or in the transmission corridors around this interconnector in Victoria and South Australia that are not being addressed by the relevant TNSPs in their transmission annual planning reports. Table F.2 provides a summary of identified constraints relating to the Heywood interconnector and how these constraints are being addressed by AEMO and ElectraNet in their transmission annual planning reports.

**Table F.2 Identified constraints relating to the Heywood interconnector and projects addressing these**

| Report limitation identified | Details of constraint | Project addressing constraint | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint) | A transmission limitation on the Northern South Australia to Adelaide 275 kV corridor as a potential economic constraint.<br><br>AEMO considers this constraint may bind during high levels of wind generation in the North South Australia zone. | Applying dynamic line ratings to the Davenport to Robertstown 275 kV lines (ElectraNet). | The timing of this potential project is dependent upon the SA renewable generation expansion scenario, but expected to be within ten years. |
| | | Various projects covered in more detail in F.3.4 (ElectraNet). | These are potential projects, some taking between 1 and 7 years, and some including a RIT-T. |
| NTNDP for 2016 (economic | Transmission limitations on the Tailem | Uprating the Tailem Bend to Tungkillo 275 kV line and the Tailem | Works on Tailem Bend to Tungkillo have been |

83 ibid, p73.

| Report limitation identified | Details of constraint | Project addressing constraint | Project status |
|---|---|---|---|
| constraint) | Bend-Tungkillo transmission corridor. | Bend to Mobilong 132 kV line from 80°C design clearances to 100°C design clearances. It will increase the transfer capacity of lines that are forecast to constrain the Heywood interconnector following its upgrade, enabling higher transfers across the Tailem Bend to Tungkillo corridor by about 132 MVA (ElectraNet). | completed as of August 2016. Works on Tailem Bend to Mobilong have also been completed, but minor works and process are required to be finalised before the improved ratings can be released. |
| | | String vacant 275 kV circuit between Tailem Bend and Tungkillo and install dynamic reactive support at Tailem Bend (ElectraNet). | A potential project taking up to 4 years; 1-2 years to undertake a RIT-T and 2 years for delivery. |

# G Review of Murraylink interconnector

All transmission network constraints on the Murraylink interconnector are being addressed by the relevant TNSPs in their annual planning reports. Similarly, all network constraints in the main transmission corridors around the interconnector in Victoria and South Australia are being addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning powers.

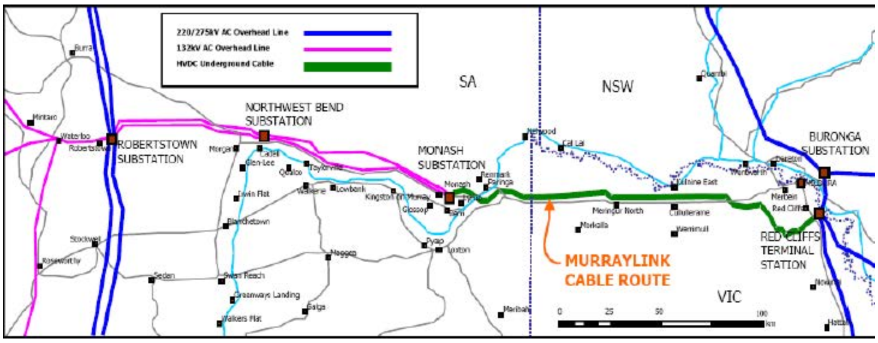
This section provides the Commission's analysis of whether there are any constraints on or around the Murraylink interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. It includes:

- an overview of the Murraylink interconnector;
- a review of the binding constraint equations that most often set the limits on this interconnector from the NEM constraint report for 2015 published by AEMO;
- a review of the emerging transmission network constraints affecting this interconnector from the NTNDP for 2016, published by AEMO in November 2015;
- a review of ElectraNet and AEMO's 2016 transmission annual planning reports on projects to address constraints on the interconnector and the main transmission corridors; and
- a summary of the projects identified to reduce transmission network constraints.

## G.1 Overview of Murraylink interconnector

Murraylink is a 220 MW direct current link between Red Cliffs in Victoria and the Monash substation near Berri in South Australia as set out in Figure G.1. It was commissioned in 2002 and is owned by Energy Infrastructure Investments Pty Ltd.

### Figure G.1 Murraylink interconnector




Source: Australian pipeline trust, Acquisition of Murraylink Transmission Company, 30 March 2006.

The interconnector connects the County Victoria zone with the North South Australia zone. The wider Country Victoria zone includes load centres such as Geelong and Ballarat, and it links to the Melbourne and Northern Victoria zones. The North South Australia zone, which covers the Mid-North, Upper North, Eyre Peninsular and Riverland areas, accounts for approximately 20 per cent of the region's total demand. The zone is connected to the Adelaide zone via four 275 kV circuits and one 132 kV circuit.

## G.2 Findings from the NEM constraint report for 2015

Many of the thermal issues closer to Murraylink are handled by the South Australian or Victorian Murraylink runback schemes.[84] Along with other interconnectors to Victoria (Victoria–New South Wales, Heywood and Basslink), Murraylink appears in many of the Victorian constraint equations. This can lead to situations where many or all of these interconnectors can be limited due to the same network limitation.

Transfers from Victoria to South Australia on Murraylink are mainly limited by thermal overloads on the South Morang F2 transformer, South Morang–Denderang 330 kV line, Ballarat–Bendigo 220 kV line, or Ballarat North to Buangor 66 kV line. Alternatively these flows may be limited by the voltage collapse limit for loss of the Darlington Point–Buronga (X5) 220 kV line for an outage of the NSW Murraylink runback scheme. Murraylink transfers from South Australia to Victoria are limited by thermal overloads on the Robertstown–Monash 132 kV lines, the Denderang–Murray 330 kV lines, or the Robertstown transformers.

In 2015 and 2014, the number of hours at each flow level on Murraylink was very similar. The main difference in 2015 was a decrease at higher flows into Victoria, and an increase in binding hours at 0 MW.[85]

The top three most binding system normal constraints on the Murraylink in each direction are outlined in Table G.1.

### Table G.1 Binding constraint equations setting the Murraylink limits in 2015

| **Victoria to South Australia limits** | | | |
|---|---|---|---|
| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
| V::N_NILxxx<br><br>(This constraint was | 977.1 | To prevent transient instability for fault and trip of a | $117,936 (number seven in top ten constraints with |

84 These schemes allow higher pre-contingency flows on Murraylink due to automatic post-contingency action returning the network to a secure state.

85 AEMO, NEM constraint report 2015, May 2016, pp26-27.

| | | | |
|---|---|---|---|
| also identified on the QLD-NSW, Vic-NSW, Heywood, and Basslink interconnectors). | | Hazelwood to South Morang 500 kV line.<br><br>AEMO notes that there are twelve constraint equations that make up the transient stability export limit from Victoria and all the binding results have been combined. | largest market impact in Victoria). |
| V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P<br><br>(This constraint was also identified on the QLD-NSW, Vic-NSW, Heywood, and Basslink interconnectors). | 853.7 | To avoid overloading the South Morang 500/330 kV (F2) transformer for no contingencies, for radial/parallel modes and Yallourn W1 on the 500 or 220 kV<br><br>These constraint equations maintain flow on the South Morang F2 transformer below its continuous rating. | $97,998 (number ten in top ten constraints with largest market impact in Victoria). |
| N^^V_NIL_1<br><br>(This constraint was also identified on the Victoria-NSW interconnector). | 185.4 | To avoid voltage collapse for loss of the largest Victorian generating unit. | $94,201 (number three top ten constraints with largest market impact in NSW). |
| **South Australia to Victoria limits** | | | |
| S>V_NIL_NIL_RBNW | 451.8 | To avoid overloading the North West Bend to Robertstown 132 kV line on no line trips.<br><br>AEMO notes that this constraint normally sets the upper limit on Murraylink. | $270,134 (number one in top ten constraints with largest market impact in South Australia). |
| S>>V_NIL_RBTX_MW4RB | 83.1 | To avoid overloading Morgan Whyalla 4 to Robertstown line on trip of one Robertstown 275/132kV transformer. | $6,013 (not in top ten constraints with largest market impact in South Australia or Victoria). |
| S::V_SA_PSS_2 | 8.4 | To maintain maximum transfer limit on SA-VIC and Murray link | $5,834 (not in top ten constraints with largest market impact in South Australia or |

| | | | |
|---|---|---|---|
| | | combined to avoid oscillatory instability when both Northern Power Station and Play ford Power Station are out of service (Note: Both Para & South East static VAr compensator assumed to be in service). | Victoria). |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2016 and *NEM constraint report 2015 supplementary data*, May 2016.

## G.3 Network constraints on the Murraylink interconnector

### G.3.1 Findings from the NTNDP for 2016

The NTNDP for 2016 identifies several potential economic constraints in relation to the Murraylink interconnector for the 2034-35 forecast period.

In the South Australia region these economic constraints include:[86]

- a limitation on the North South Australia to Adelaide 275 kV corridor as a potential economic constraint (applies under the Gradual Evolution scenario in both the base and sensitivity case).
- a limitation on the 132 kV transmission network in the Mid North region of South Australia (applies under all NTNDP scenarios and sensitivities).
- a limitation on the 132 kV transmission network in the Riverland area of South Australia (applies under all NTNDP scenarios and sensitivities).

AEMO considers the above constraints may bind during high levels of wind or solar generation in the North South Australia zone.

AEMO identifies another potential economic constraint in the South Australia region as a transmission limitation along Tailem Bend-Tungkillo transmission corridor. AEMO considers this will occur when there is new generation in South East Australia zone or there is high import from Victoria and under the Rapid Transformation scenario (under both the base and sensitivity case).[87]

86 AEMO, *National Transmission Network Development Plan*, November 2015, p21.

87 ibid.

Regarding connections to neighbouring zones in Victoria, the NTNDP for 2016 identifies a potential economic constraint in the Central Victoria zone relating to transmission limitations on the Ballarat-Horsham 220 kV line. AEMO considers this constraint may bind during high levels of wind generation connected between Ballarat and Horsham and/or between Horsham and Redcliffs.[88] This constraint only applies under the "Gradual Evolution" base case scenario (without the sensitivity).

### G.3.2 Findings from AEMO's 2016 Victorian transmission annual planning report

AEMO does not identify any projects in Victoria along the transmission corridors leading to the Murraylink interconnector. However, AEMO identifies projects in the Regional Victoria zone which relate to the Victoria-NSW interconnector in Appendix E which may also be relevant to the Murraylink interconnector.

AEMO will commence a RIT-T for augmentation in North West Victoria later this year to alleviate congestion between Ballarat and Horsham's 220 kV line. AEMO identifies this as an economic constraint affecting transmission flow in the NTNDP. Consultation in the RIT-T will assess potential augmentation benefits in more detail, and invites stakeholders to engage in discussions about proposed generation projects.[89]

### G.3.3 Findings from ElectraNet's 2016 South Australian transmission annual planning report

As detailed in section F.3.4, ElectraNet considers as part of its planning process three scenarios:

- a base scenario which was ElectraNet's central planning scenario (the base scenario);
- a scenario which considers a number of potential future mining loads (the SA mining growth scenario); and
- a scenario that represents an extreme yet possible future expansion of SA wind generation (the SA renewable generation expansion planning scenario).

ElectraNet directly addresses each of the potential economic constraints noted in the NTNDP for 2016 in their region in their 2016 annual planning report and identifies projects which respond to those limitations.

ElectraNet addresses the potential economic constraint on the Northern South Australia-Adelaide 275 kV corridor by identifying several potential projects, including:

- applying dynamic line ratings to the Davenport to Robertstown 275 kV lines. The project is identified to commence within ten years, with an estimated cost of less

88 AEMO, *National Transmission Network Development Plan*, November 2015, p21.

89 AEMO, *Victorian annual planning report*, June 2016, p26.

than $5 million and is subject to the demonstration of market benefits. This potential project is contingent upon the SA renewable generation expansion planning scenario.[90]

- rebuilding Davenport–Brinkworth–Para 275 kV as a high capacity 275 kV AC double circuit line with twin conductors. The project would take up to 7 years to complete, with 1-2 years to undertake a RIT-T and 5 years easement acquisition, detailed design and delivery.[91]
- strengthening the Mid North 275 kV network through various line uprating and application of dynamic line ratings depending on generator developments. The commencement for this project is expected to be within 2 to 3 years.[92]
- tie Davenport to Robertstown 275 kV at Belalie Substation. This project would take up to 4 years to complete, including 1-2 years to undertake a RIT-T and 2 years detailed design and delivery.[93]

ElectraNet addresses the potential economic constraint on the 132 kV transmission network in the Mid North region of South Australia by identifying a potential project to strengthen the Mid North 275 kV network. This involves the uprating of various lines and the application of dynamic line ratings depending on generator developments.[94]

ElectraNet addresses the potential economic constraint on the 132 kV transmission network in the Riverland area of South Australia by identifying two potential projects. The first is a potential new interconnector between South Australian and either Victoria or New South Wales. This project would take up to 7 years, with 1-2 years to undertake a RIT-T and 5 years for delivery. The second potential project is ElectraNet's engagement with APA (as operator of Murraylink), AusNet Services as the declared transmission system operator in Victoria and AEMO to assess the technical feasibility, cost and potential benefits of implementing frequency control through the Murraylink interconnector. The focus of this work is on the provision of regulation FCAS for South Australia. There are no timings associated with this project as it is ongoing.[95]

There are other projects ElectraNet identifies which may have an impact inter-regional transmission flow paths on the Murraylink interconnector. These include:

- the planned uprating of the Robertstown to North West Bend No. 2 132 kV line and the North West Bend to Monash No. 2 132 kV line from 80°C design clearances to 100°C design clearances. ElectraNet reports this as a committed

90 ElectraNet, *South Australian transmission annual planning report*, June 2016, p71.

91 ibid, p36.

92 ibid.

93 ibid.

94 ElectraNet, *South Australian transmission annual planning report*, June 2016, Table 4-4, p36.

95 ElectraNet, *South Australian transmission annual planning report*, June 2016, Table 4-3, p35.

project contingent upon its base scenario commencing June 2017 for this project and at an estimated cost of less than $5 million.[96]

- uprating the Waterloo East to Robertstown 132 kV line from 80°C design clearances to 100°C design clearances. This project is expected to enable increased power export to Victoria under high Riverland demand by about 37 MW. ElectraNet reports this is a committed project contingent upon its base scenario with a commencement of June 2018 and an estimated cost of less than $5 million.[97]
- installing reactive support at Monash through up to two 15 MVar 132 kV capacitors being installed at Monash. This would improve 132 kV voltage levels on the Riverland 132 kV network during times of high power transfer, and support greater available exports across the Murraylink interconnector. ElectraNet reports this as a potential project contingent upon its SA mining growth scenario commencing within 10 years and an estimated cost of less than $5 million.[98]

## G.4 Summary of projects for identified network constraints

There are no transmission network constraints on the Murraylink interconnector or in the transmission corridors around this interconnector in Victoria and South Australia that are not being addressed by the relevant TNSPs in their transmission annual planning reports. Table G.2 provides a summary of the projects impacting on the Murraylink interconnector that in relevant planning documents and how these constraints are being addressed in AEMO and ElectraNet's 2016 transmission annual planning reports.

**Table G.2 Identified constraints relating to the Murraylink interconnector and how these are being addressed**

| Report limitation identified | Constraint details | Project to address constraint | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint). | A transmission limitation on the Northern South Australia to Adelaide 275 kV corridor.<br><br>AEMO considers this constraint may bind during high levels of wind generation in the North South Australia zone. | Applying dynamic line ratings to the Davenport to Robertstown 275 kV lines (ElectraNet). | Commencement of the potential project is within ten years. |
| | | Various projects contained in G.3.3 (ElectraNet). | Several potential projects, taking between 1 and 7 years, including some of them having RIT-Ts. |

96 ElectraNet, *South Australian transmission annual planning report*, June 2016, p65.

97 ElectraNet, *South Australian transmission annual planning report*, June 2016, pp65-66.

98 ElectraNet, *South Australian transmission annual planning report*, June 2016, p74

| Report limitation identified | Constraint details | Project to address constraint | Project status |
|---|---|---|---|
| NTNDP for 2016 (economic constraint). | A transmission limitation on the 132 kV transmission network in the Mid North region of South Australia.<br><br>AEMO considers this constraint may bind during high levels of wind generation in the North South Australia zone. | Reconfiguring of the Mid North 275 kV network. This involves the various potential reconfiguration options depending on generator and load developments (ElectraNet). | A potential project dependent on location of generation and load. |
| NTNDP for 2016 (economic constraint). | A transmission limitation on the 132 kV transmission network in the Riverland area of South Australia.<br><br>AEMO considers this constraint may bind during high levels of wind generation in the North South Australia zone. | A new interconnector between South Australia and either Victoria or New South Wales (ElectraNet). | This is a potential project with a lead time for the new interconnector project is 1-2 years to undertake a RIT-T and 3-5 years to undertake detailed design and delivery. |
| | | ElectraNet is engaging with APA (operator of the Murraylink interconnector); AusNet Services; and AEMO, in its capacity as the Victorian transmission network planner, to consider the technical feasibility, cost, and potential benefits of implementing frequency control through the Murraylink interconnector. (ElectraNet). | A potential project with no timing is reported for this project. |
| NTNDP for 2016 (economic constraint). | A transmission limitation in the Central Victoria zone on the Ballarat-Horsham 220 kV line.<br><br>AEMO considers this constraint may bind during high levels of wind generation | No particular project is identified, but AEMO will commence a RIT-T for augmentation in North West Victoria later this year (AEMO). | This is a potential project subject to the RIT-T process. |

| Report limitation identified | Constraint details | Project to address constraint | Project status |
|---|---|---|---|
| | connected between Ballarat and Horsham and/or between Horsham and Redcliffs. | | |

# H Review of Basslink interconnector

All transmission network constraints on the Basslink interconnector are being addressed by the relevant TNSPs in their annual planning reports. In addition, all network constraints in the main transmission corridors around the interconnector in Victoria and Tasmania are being addressed. As such, there is no evidence of insufficient consideration of an inter-regional transmission constraint that would require the Commission to direct a TNSP under its last resort planning powers.

This section provides the Commission's analysis of whether there are any constraints on or around the Basslink interconnector that are not being addressed by the relevant TNSPs in their annual planning reports. It includes:

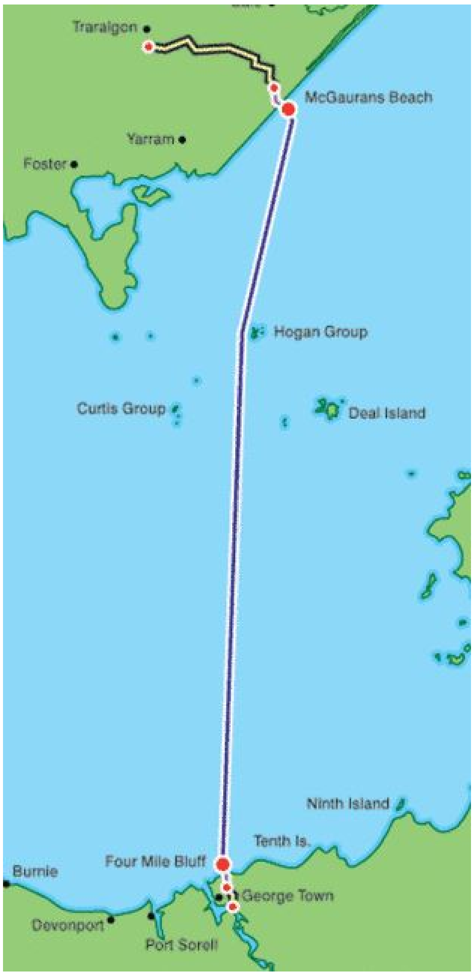
- an overview of the Basslink interconnector;
- a review of the binding constraint equations that most often set the limits on this interconnector from AEMO's NEM constraint report for 2015;
- a review of the emerging transmission network constraints affecting this interconnector from the NTNDP for 2016, published in November 2015;
- a review of TasNetworks' and AEMO's 2016 transmission annual planning reports on projects to address constraints on the interconnector and the main transmission corridors; and
- a summary of the projects identified to reduce transmission network constraints.

## H.1 Overview of Basslink interconnector

Victoria and Tasmania are connected via the Basslink interconnector. Basslink is a direct current interconnection between George Town in Tasmania and Loy Yang in the Latrobe Valley area in Victoria as set out in Figure H.1. It is an unregulated market link that was commissioned in early 2006 after Tasmania joined the NEM. Basslink is owned by Keppel Infrastructure Trust.[99] Unlike the other direct current lines in the NEM, Basslink has a frequency controller and is able to transfer frequency control ancillary services between Tasmania and the mainland.

99 Keppel Infrastructure was known as CitySpring Infrastructure until 18 May 2015.

**Figure H.1 Basslink interconnector**




Source: Basslink website, www.basslink.com.au, viewed 9 November 2015.

The Latrobe Valley area has a significant amount of coal-fired generation. It is a major exporter of energy, principally to Melbourne and Moorabool through to Heywood (via its 500 kV and 220 kV transmission networks – the 'Eastern corridor'), and also to Regional Victoria and Tasmania. The Tasmanian region has a significant amount of hydroelectric generation. This generation is geographically dispersed across the region.

As Basslink is an unregulated market interconnector and not a TNSP, it is not required to apply the RIT-T to address an identified investment need on the interconnector. Therefore, if the Commission identified a deficiency in the planning arrangements of the interconnector it would not be able to direct Basslink to carry out a RIT-T under the last resort planning power. However, if the identified constraints could be alleviated in the transmission corridors connecting to Basslink, or through the construction of another interconnector, the Commission could direct the TNSP in Victoria, Tasmania or both to undertake a RIT-T.

## H.2 Findings from the NEM constraint report for 2015

AEMO reports that the majority of constraints on Basslink transfers are due to frequency control ancillary service constraint equations for both mainland and Tasmanian contingency events.

Tasmania to Victoria transfers are mainly limited by the energy constraint equations for the South Morang F2 transformer overload, or the transient over-voltage at George Town. For Basslink flows from Victoria to Tasmania, the energy constraints are due to the transient stability limit for a fault and trip of Hazelwood–South Morang line.

Up until 2014, most flows and binding hours on Basslink were from Tasmania to Victoria. Similar to 2014, in 2015 this reversed with nearly 1,100 hours of flows of 480 MW into Tasmania. There were very few binding hours from Tasmania to Victoria in 2015.[100]

The top three most binding system normal constraints on the Basslink in each direction for 2015 are outlined in Table H.1.

**Table H.1 Binding constraint equations setting the Basslink limits in 2015 (system normal)**

| **Tasmania to Victoria limits** | | | |
|---|---|---|---|
| **Equation ID** | **Hours binding in 2015** | **Description** | **Market impact (with position in top ten market impacts per region)[a]** |
| V>>V_NIL_2A_R & V>>V_NIL_2B_R & V>>V_NIL_2_P<br><br>(This constraint was also identified on the Victoria–New South Wales, Heywood and Murraylink interconnectors). | 859.5 | To avoid overloading the South Morang 500/330 kV (F2) transformer for no contingencies, for radial/parallel modes and Yallourn W1 on the 500 or 220 kV.<br><br>AEMO notes that these constraint equations maintain flow on the South Morang F2 transformer below its continuous rating. | $97,998 (number ten in top ten constraints with a market impact in Victoria). |
| TVBL_ROC | 12.1 | A rate of change limit (200 MW / 5 minute) for Basslink. | $30,580 (number four in top ten constraints with a market impact in |

100 AEMO, *NEM constraint report 2015*, May 2016, p27 and *NEM constraint report 2015 supplementary data*, May 2016.

| | | | |
|---|---|---|---|
| | | | Tasmania). |
| T^V_NIL_8 | 5.5 | Tamar Valley Combined Cycle Gas Turbine Out of Service prevent voltage collapse at Georgetown 220 kV bus for loss of a Sheffield to George Town 220 kV line, swamped if Tamar Valley Combined Cycle in service. | $453 (does not appear in top ten constraints with a market impact in Tasmania or Victoria). |
| **Victoria to Tasmania limits** | | | |
| V_T_NIL_FCSPS | 475.7 | Basslink limit from Victoria to Tasmania for load enabled for the Basslink frequency control special protection scheme. | $108,206 (number eight in top ten constraints with a market impact in Victoria). |
| V::N_NILxxx<br><br>(This constraint was also identified on the QLD-NSW, Vic-NSW, Heywood and Murraylink interconnectors). | 409.1 | To prevent transient instability for fault and trip of a Hazelwood to South Morang 500 kV line. | $117,936 (number seven in top ten constraints with a market impact in Victoria). |
| V_T_NIL_BL1 | 382.3 | Basslink no go zone limits Victoria to Tasmania. | $160,102 (number five in top ten constraints with a market impact in Victoria). |

[a] The market impact is calculated by adding up the marginal values from the marginal constraint cost re-run. To that end, the constraint is relaxed marginally (by 1 MW). This will result in a different dispatch pattern, with different associated costs, compared to the situation under the full constraint. This is done for each dispatch interval during the number of hours a constraint was binding. These values are subsequently added up to provide a total marginal market impact.

Source: AEMO, *NEM constraint report 2015*, May 2015 and *NEM constraint report 2015 supplementary data*, May 2015.

## H.3 Network constraints on the Basslink interconnector

### H.3.1 Findings from the NTNDP for 2016

AEMO does not forecast any reliability or economic driven network constraints for Basslink and the transmission lines around it in the NTNDP for 2016 during the outlook period to 2034-35.

However, AEMO identifies two potential economic dispatch constraints in Tasmania.[101] In particular it considers possible constraints in the Burnie to Sheffield transmission corridor and the Farrell to Sheffield transmission corridor at times of high wind generation in northwest and west Tasmania, respectively.[102]

The NTNDP for 2016 does not identify any transmission network constraints in the eastern corridor in the Latrobe Valley and into Greater Melbourne over the outlook period.

### H.3.2 Findings from AEMO's 2016 Victorian transmission annual planning report

AEMO identifies two transmission network constraints in the eastern corridor from Basslink through the Latrobe Valley into Greater Melbourne in its 2016 transmission annual planning report.[103]

The first constraint is a Rowville–Yallourn 220 kV line loading limitation. AEMO identifies two potential options to resolve the limitation:

- installing a new 500/220 kV transformer at Hazelwood with an estimated cost of $36 million plus any fault level mitigation works; or
- upgrading the 220 kV Hazelwood– Rowville or Yallourn–Rowville lines.

The second constraint is a Hazelwood 500/220 kV transformer loading limitation. AEMO identifies two potential options to resolve the limitation:

- installing a new 500/220 kV transformer at Hazelwood with an estimated cost of $36 million plus any fault level mitigation works; or
- upgrading the 220 kV Hazelwood–Rowville or Yallourn–Rowville lines.

Both of the constraints are triggered during periods of extremely high temperature and high output from Hazelwood or Yallourn power stations. These constraints were not identified in the NTNDP for 2016.

### H.3.3 Findings from TasNetworks' 2016 Tasmanian transmission annual planning report

TasNetworks proposes similar investments in its 2016 annual planning report compared to its 2015 annual planning report. TasNetworks identifies its network capability improvement parameter action plan (NCIPAP) augmentations as relevant to

101 Both of these constraints are not inter-regional in nature. This assessment is based on advice given to the AEMC by AEMO staff on 15 August 2016.

102 AEMO, *National Transmission Network Development Plan*, November 2015, p21.

103 AEMO, *Victorian annual planning report*, June 2016, p34.

constraints identified in the NTNDP for 2016.[104] These constraints are intra-regional in nature as opposed to inter-regional which is the subject of the LRPP.

## H.4 Summary of projects for identified network constraints

In summary, AEMO have not identified any transmission network constraints on the Basslink interconnector, or in the transmission corridors around this interconnector in Victoria and Tasmania that are inter-regional in nature. Therefore, constraints are being adequately addressed by TNSPs.

However, the Commonwealth and Tasmanian Governments have initiated a feasibility study on a second interconnector from Tasmania to Victoria. The purpose of this study is to assess:

- the potential for a second interconnector to facilitate large scale renewable investment in Tasmania;
- how a second interconnector could contribute to system security, both in Tasmania and in the NEM more broadly; and
- the costs and benefits to consumers, both in Tasmania and the NEM, of a second interconnector from Tasmania to Victoria.[105]

A preliminary report on the study was released on 21 June 2016. A final report is due by the end of January 2017.[106]

104 TasNetworks, *Annual Planning Report 2016*, June 2016, p65.

105 Commonwealth of Australia, *Feasibility of a second Tasmanian interconnector: Preliminary Repor*t, June 2016, pp6, 40-41.

106 See more: www.industry.gov.au/Energy/Pages/Tasmanian-Energy-Taskforce.aspx, viewed 28 September 2016.